## 6.1 SPACE TECHNOLOGY

It is a very dynamic technology of the space science or the aerospace industry, serving various applications like satellites, shuttles, spaceflights and various space exploration work. Space technology has a multidimensional role in human life and caters to everyday services like weather forecasting, remote sensing, DTH, business networking, GPS systems, etc. Astronomy and Earth Science (via remote sensing) also greatly benefit from space technology. It is also an income-generation industry to send various foreign satellites and also provides other benefits to many recipient nations.

## 6.2 INDIAN SPACE RESEARCH PROGRAMME (ISRP)

**Vikram Sarabhai** is the pioneer of the Indian Space Programme with various objectives in the promotion of science and technology application and development for the country's socio-economic benefit.

These objectives are:

1. Peaceful purposes of outer space.
2. Operational space services will establish in a self-sufficient manner.
3. In the beginning, Indian Space Programme was involved in the designing and fabrication of satellites and development of launch vehicles to launch various satellites.

## 6.3 INSTITUTIONAL SETUP

In the year 1962, **Indian National Committee for Space Research (INCOSPAR)** was formed under Dr. Vikram Sarabhai, to formulate Space Programme of India. On the recommendation of this committee, ISRO was formed (**Figure 6.1**). The formulation of ISRO, thus regularised the country's space activities. Now, it is under the control of the Department of Space (DoS) and reports to the Prime Minister.

### *Department of Space (DoS)*

Department of Space (DoS) is the nodal agency for space activities in India and have various features:

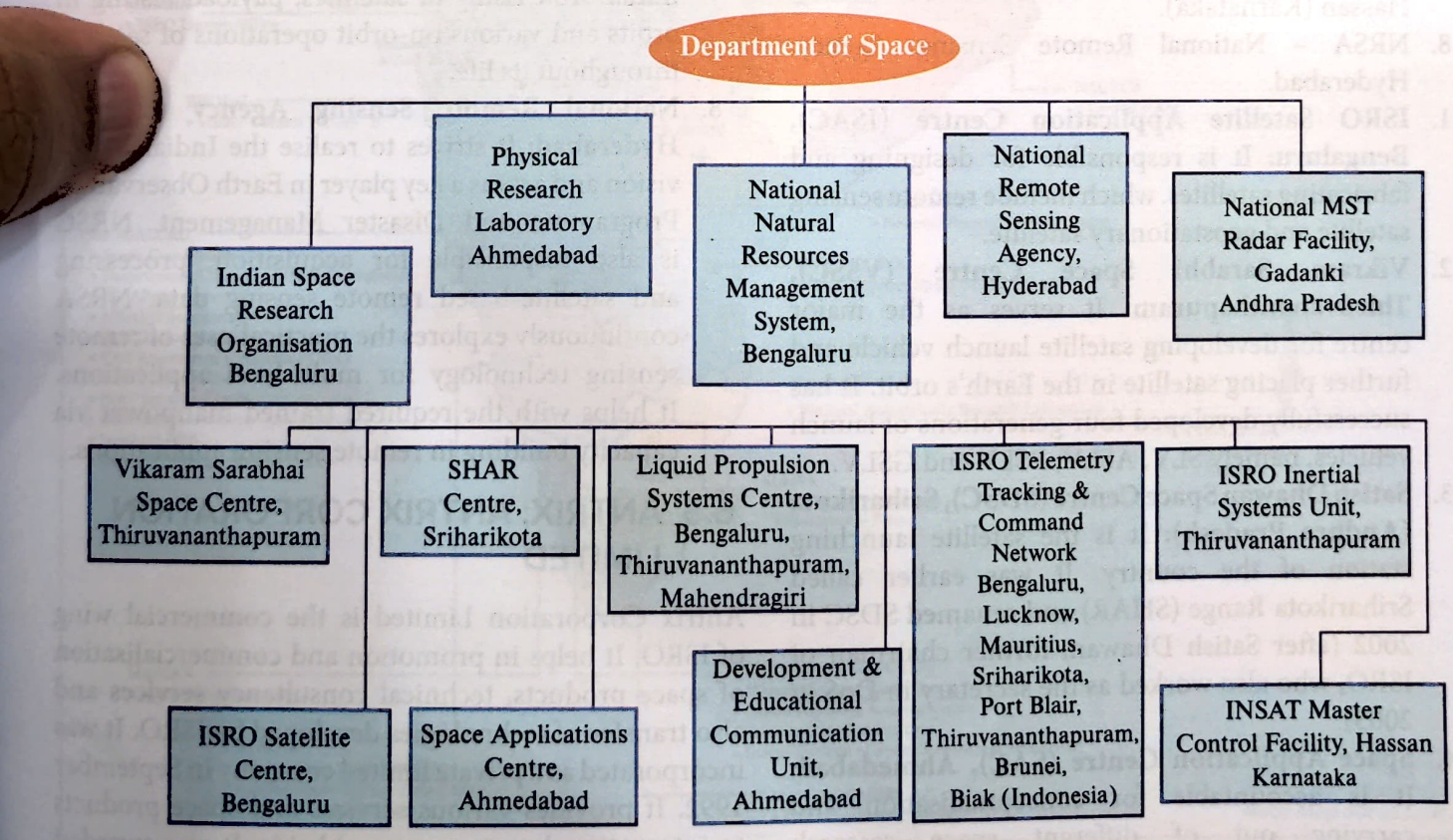

Department of Space
Indian Space Research Organisation Bengaluru
Physical Research Laboratory Ahmedabad
National Natural Resources Management System, Bengaluru
National Remote Sensing Agency, Hyderabad
National MST Radar Facility, Gadanki Andhra Pradesh
Vikaram Sarabhai Space Centre, Thiruvananthapuram
SHAR Centre, Sriharikota
Liquid Propulsion Systems Centre, Bengaluru, Thiruvananthapuram, Mahendragiri
ISRO Telemetry Tracking & Command Network Bengaluru, Lucknow, Mauritius, Sriharikota, Port Blair, Thiruvananthapuram, Brunei, Biak (Indonesia)
ISRO Inertial Systems Unit, Thiruvananthapuram
ISRO Satellite Centre, Bengaluru
Space Applications Centre, Ahmedabad
Development & Educational Communication Unit, Ahmedabad
INSAT Master Control Facility, Hassan Karnataka

**Figure 6.1**
Various Institutions and Organisations under the Department of Space (DoS)

space infrastructure, space transportation systems and at international level, it also involves in the outer space activities, governed by the United Nations (UN) treaties and principles evolved under **UN Committee on Peaceful Uses of Outer Space** (COPUOS) in particular.

## 6.4 ISRO AND ITS PROMINENT REGIONAL CENTRES

ISRO plays a leading role in India for space research with the help of various prominent regional centres (**Figure 6.2**). These are given below:

1. ISAC – ISRO Satellite Application Centre, Bengaluru.
2. VSSC – Vikram Sarabhai Space Centre, Thiruvananthapuram.
3. SDSC – Satish Dhawan Space Centre, Sriharikota.
4. SAC – Space Application Centre, Ahmedabad.
5. LPSC – Liquid Propulsion System Centre, Mahendragiri, Tamil Nadu.
6. ISTRAC – ISRO Telemetry, Tracking and Command Network, Bengaluru.
7. MCF – Master Control Facility, Bhopal (MP) and Hassan (Karnataka).
8. NRSA – National Remote Sensing Agency, Hyderabad.

1. **ISRO Satellite Application Centre (ISAC), Bengaluru:** It is responsible for designing and fabricating satellites, which include remote sensing satellite and geostationary satellite.
2. **Vikram Sarabhi Space Centre (VSSC), Thiruvananthapuram:** It serves as the major centre for developing satellite launch vehicle and further placing satellite in the Earth's orbit. It has successfully developed four generations of launch vehicles, namely SLV, ASLV, PSLV and GSLV.
3. **Satish Dhawan Space Centre (SDSC), Sriharikota (Andhra Pradesh):** It is the satellite launching station of the country. It was earlier called Sriharikota Range (SHAR) and renamed SDSC in 2002 (after Satish Dhawan, former chairman of ISRO, who also worked as the secretary in DoS in 2005).
4. **Space Application Centre (SAC), Ahmedabad:** It is accountable for conceptualisation and carrying out of different space research projects. Besides, it also conducts research anchoring the practical space technology application for usage of civilians.
5. **Liquid Propulsion System Centre, Mahendragiri (LPSC), Tamil Nadu:** It is responsible for Satellite Propulsion Systems Integration for Geostationary Satellite and IRS programmes. India has developed its own cryogenic engine here.
6. **ISRO Telemetry, Tracking and Command Network (ISTRAC), Bengaluru:** It is responsible for providing various space operation services like spacecraft control, launch vehicle and low Earth orbiting spacecrafts with various deep space missions of ISRO and other space agencies around the world. The additional responsibilities of ISTRAC include development of RADAR systems for tracking and atmospheric applications and establishing Ground Segment Network for Indian Regional Navigation Satellite System.
7. **Master Control Facility (MCF), Hassan in Karnataka and Bhopal in Madhya Pradesh:** They observe and control all the geostationary satellites. They also carry out operations related to initial orbit rising of satellites, payload testing in orbits and various on-orbit operations of satellite throughout its life.
8. **National Remote Sensing Agency (NRSA), Hyderabad:** It strives to realise the Indian space vision and acts as a key player in Earth Observation Programme and Disaster Management. NRSC is also responsible for acquisition, processing and satellite-based remote sensing data. NRSA continuously explores the practical uses of remote sensing technology for multi-level applications. It helps with the required trained manpower via capacity building in remote sensing applications.

## 6.5 ANTRIX: ANTRIX CORPORATION LIMITED

Antrix Corporation Limited is the commercial wing of ISRO. It helps in promotion and commercialisation of space products, technical consultancy services and also transfer of technologies developed by ISRO. It was incorporated as a private limited company in September 1992. It provides various services and space products to international customers worldwide. It was awarded 'Miniratna' status by the government in 2008.

**SPACE-BASED PROGRAMME**

**1. YUVIKA – Yuva Vigyani Karyakram (Young Scientist Programme)**

- ISRO is organising a special programme for School Children called '**Young Scientist Programme**' YUVIKA, to impart basic knowledge on Space Technology, Space Science and Space Applications to the younger students in emerging trends in space science and technology amongst youngsters.
- The main thought behind the programme is to '**Catch Them Young**'.
- The programme is also expected to encourage more students to pursue in **Science, Technology, Engineering and Mathematics (STEM)**-based research/career.
- STEM education is an interdisciplinary programme that **provides a platform for innovation and creativity.** STEM education is now being made a part of the curriculum right from the elementary school. STEM education is different from regular science and mathematics. It talks about the **application of these techniques into the real world,** i.e., an integrating applied approach and cohesive learning techniques.

**2. UNNATI – Unispace Nanosatellite Assembly & Training by ISRO**

- ISRO, Department of Space, Government of India offers a **training programme on nanosatellite assembly and building** named UNNATI (Unispace Nanosatellite Assembly & Training).
- **Eligibility: Foreign Engineers/Scientists/Officials are eligible to get trained.**
- The **training provides an opportunity for the participating countries to strengthen their capabilities in assembling, integrating and testing nanosatellites.**
- India **announced this programme in 2018 in Vienna** during the Symposium to commemorate the 50$^{th}$ Anniversary of the First United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50).
- A total of 60 participants from 33 countries benefited from a 2-months residential programme.
- **The programme is conducted at ISRO's U.R. Rao Satellite Centre (URSC), Bengaluru.**

*Missions*

- Satellites and its related technology development and design for Earth observation, communication, navigation, meteorology and space science.
- Launch vehicles and its related technologies development and design for providing access of space.
- Indian National Satellite (INSAT) programmes for telecommunication, television broadcasting and development applications.
- Space-based applications for societal development and disaster management support.
- Management of natural resources and monitoring of environment using space-based imagery by Indian Remote Sensing Satellite (IRS) programme.
- Research and development in space science and planetary exploration.

## 6.6 NEW SPACE INDIA LIMITED COUNCIL (NSIL)

New Space India Limited (NSIL) had been ***incorporated in 2019,*** **as a wholly owned Government of India Undertaking/Central Public Sector Enterprise (CPSE)** control of Department of Space (DoS) to commercially exploit the research and development work of Indian Space Research Organisation (ISRO) centres and constituent units of DoS. The company will spearhead ***various space products including production of launch vehicles, transfer of technologies and marketing of space products.***

*Role of NSIL*

- Small satellite technology transfer to industry, wherein the new company shall take licence from DoS/ISRO and sub-licence to industries.
- Manufacture of small satellite launch vehicle (SLV) in collaboration with the private sector.
- Product ionisation of Polar SLV through industry.
- Marketing of some spin-off technologies and products, both in India and abroad and any other subject which the Government of India deems fit.
- Product ionisation and marketing of space-based products and services, including launch and applications.

**HOW NSIL IS DIFFERENT FROM ANTRIX?**

- ISRO already has a commercialisation arm Antrix Corporation Ltd. that looks at foreign markets. But as ISRO's capabilities expand and collaboration with industries increase, there is a need to expand the commercialisation activities as well as domestically.
- NSIL was kick started in May 2019 to monetise ISRO's research, products and services in space technology. Antrix focuses on foreign markets, but NSIL will focus on the domestic market. In the domestic space, there is a huge demand in earth observation, communication and navigation space.
- Antrix will handle ISRO's commercial deals for satellites and launch vehicles with foreign customers whereas NSIL will deal with capacity building of local industry for space manufacturing.

## 6.7 DIFFERENT TYPES OF SATELLITE ORBITS

Following are different types of satellite orbits (see **Table 6.1**):

- A satellite may orbit around the Earth in different planes. For instance, an orbit that is directly above the Earth's equator is known as equatorial orbit, while the one that passes over both poles is known as polar orbit.
- Other orbits are referred to as inclined orbits.
- The orbit may be circular (with the centre of the circle at centre of the Earth), or elliptical (with the Earth's centre at one of the two foci of the ellipse).
- The altitude of communication satellite can be Geostationary Earth Orbit (GEO), Medium Earth Orbit (MEO) or Low Earth Orbit (LEO). (Refer **Infographics – Types of Earth Orbits and Types of Orbits**).

**TABLE 6.1 Different type of orbits and their distance from Earth's surface**

| Orbit | Altitude |
|---|---|
| 1. Low Earth Orbit | 50–1500 kilometres (from the surface of Earth to 2000 kilometres distance is also considered as Low Earth Orbit) |
| 2. Medium Earth Orbit | 5000–12,000 kilometres (even 20,000 kilometres in the case of GPS) |
| 3. Geosynchronous Orbit | 35,786 kilometres (22236 miles) |
| 4. High Earth Orbit | Beyond 35,786 kilometres |

### 6.7.1 Low Earth Orbit (LEO)

- Low Earth Orbit satellites are often in polar orbit at altitude of 50–1500 kilometres and the orbital period in the range of 95–120 minutes.
- LEO satellites try to ensure a high elevation for every spot on Earth, thus providing a high-quality communication link.
- The maximum time that LEO satellites are visible from a fixed point on Earth is up to 20 minutes. LEO is further classified into little LEO with Low Bandwidth Services (almost 100 bits per second), big LEO (almost 1 kilobits per second) and broadband LEO (almost 2 millibits per second).

*Advantages of LEO*

- It can provide true globe coverage and efficient use of spectrum.
- Due to lower path loss, use of smaller terminals becomes possible.
- The propagation delay is very low (10 milliseconds).

*Disadvantages of LEO*

- The mismatch of the orbital period of satellite and Earth results in serious consideration of Doppler effect.
- It requires large number of satellites for whole coverage.
- High probability of handover during a call.
- Failed satellites require to be replaced regularly because of their lower lifetimes.

### 6.7.2 Medium Earth Orbit (MEO)

- MEO satellite can be positioned somewhere between LEO and GEO, at an altitude of around 5000–12000 kilometres above the Earth's surface with inclination towards equator plane.
- So far, there have not been many satellites in this orbit, but some upcoming systems use this orbit.
- The orbital period of MEO satellite is about 6 hours. The visibility of satellite from a fixed point on Earth is about 60–100 minutes.

*Advantages of MEO*

- It can provide true globe coverage.
- It is possible to use smaller terminal because it provides lower path loss due to less distance.

- It provides medium propagation delay (80-milli-seconds).
- MEO can cover large area, thus require less handover.

***Disadvantages of MEO***

- It requires large number of satellites for whole coverage.
- Orbital period of satellite and Earth are mis-matched, therefore Doppler Effect is considered.
- Required relatively long time to deploy a full constellation.
- Failed satellite needs to be replaced regularly due to their lower lifetime and larger number.
- The medium visibility of satellite leads to low probability of handover during call.

### 6.7.3 Geostationary Earth Orbit (GEO)

- The Geostationary Earth Orbit satellite is the most popular type of communication satellite.
- If the orbital period of satellite exactly matches the orbital period of Earth at an altitude of 35,863 kilometres above the Earth's surface and rotates in the equatorial plane of the Earth with angular velocity of 3075 metres per second, such an orbit is called geosynchronous orbit. When the inclination and the eccentricity of the orbit are zero, the satellite appears stationary to an observer on the ground. Thus, the orbit is termed as geostationary orbit.

***Advantage of GEO***

- Since the orbital period of satellite and Earth are almost same, the problem of Doppler Effect does not occur as relative motion is zero.
- The GEO satellite covers most of the inhabited portion of the Earth, excluding only the area near the north and south poles.

***Disadvantage of GEO***

- It provides relatively large propagation delay of 0.24 seconds. This affects voice and time data protocol.
- Relatively large path loss due to large distance travelled by signal.
- Relatively high launch cost.
- The polar region and far northern and southern hemispheres are poorly served by geostationary satellites.

### 6.7.4 High Earth Orbit (HEO)

Those satellite or space missions we send across the Earth's orbit (beyond 35,786 kilometres) are called as High Earth Orbit satellites, e.g. Chandrayaan-I, II, Mangalyaan I, Aditya Mission.

Note: LEO satellites are at polar position (Polar Satellite), MEO satellites are at inclined or transitional position and GEO satellites are at equatorial position for their own work.

### 6.7.5 Polar versus Polar Sun-synchronous Orbit

Polar satellite cannot be used always to take images of the Earth's surface. Only for a certain time period, this satellite will be in front of Sun, for rest of the time, due to planetary movement of Sun and Earth position change satellite will see the shadow of the Sun on the Earth surface. The only solution to this problem is polar sun-synchronous orbit where the revolution of satellite is always in front of Sun as a result of changing their own inclination angle at every revolution. Since in this orbit, satellite appears to follow the path of Sun at every moment of time, it is called as **polar sun-synchronous orbit.**

This orbit also called as **'dawn-to-dusk orbit'** because satellite trails the Earth's shadow. The shadow is cast on the opposite side rather than on the side where the Sun shines. Since the satellite never moves into this shadow, the Sun appears to always shine on it. Due to closeness of satellite to the shadow, the part of the Earth on which the satellite is directly above, is always at sunset or sunrise. Hence, this orbit is called a dawn-to-dusk orbit. This enables the satellite to always have its solar panels towards the Sun. Generally, sun-synchronous orbits are medium or low orbits. **Radarsat (Canadian satellite) is an example of a satellite in a low sun-synchronous orbit. Radarsat is in orbit at 798 kilometres above Earth, at an angle of inclination of 98.6 degrees to the equator, as it circles the globe from pole to pole.** To keep its solar panels facing the Sun almost constantly, Radarsat relies on its dawn-to-dusk orbit. Radarsat can, henceforth, rely mostly on solar power rather than batteries.

(Refer Infographic – Sun-Synchronous Orbit)

### 6.7.6 Transfer Orbit

It is an intermediate orbit into which a satellite is released and from here, the satellite will subsequently be lifted up by making noise of its propulsion system.

### 6.7.7 GPS Orbit/Semi-synchronous Orbit's

**GPS Orbit/Semi-synchronous Orbits** (Figure 6.3) is an elliptical orbit at an altitude of about 5000–12,000 kilometres used for navigation purpose. A constellation of 24–36 satellites in MEO orbit (inclined or transitional in position) will be utilised to cover world navigation in Global Positioning Systems (e.g. **NAVSTAR** and **GLONASS).** Three geostationary satellites can be used to cover the entire surface of Earth except polar area, so it cannot be used in global navigation system. In a country like India (those which are near to equator), for regional GPS, we can use GTO (Geosynchronous

Transfer Orbit) and GEO (Geostationary Orbit) in combination, e.g. GAGAN and IRNSS.

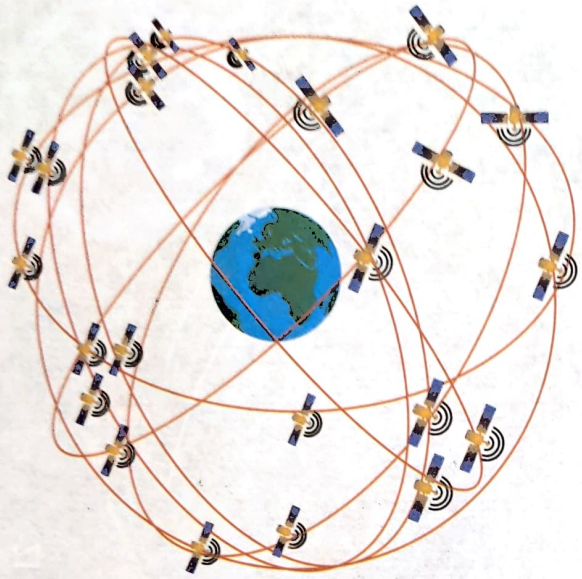


**Figure 6.3**
All GPS Satellites in Semi-synchronous Orbit

### 6.7.8 Geosynchronous Orbit versus Geostationary Orbit

A special case of geosynchronous satellite is the geostationary satellite, which has a geostationary orbit – a circular orbit directly above Earth's equator.

**Geosynchronous Orbit:** In this orbit, Earth's orbital period is equal to a sidereal day (23 hours, 56 minutes), in respect of its inclination. This implies that a person on a point on Earth will see a satellite in this orbit in the same place in the sky at the same time of the day, every day. Geosynchronous satellites have the advantage of remaining permanently in the same position in the sky, as viewed from a particular location on Earth.

**Geostationary Orbit:** A *geosynchronous* orbit around Earth at 35,786 kilometres above the equator, thus appears stationary as seen from the Earth. Just like a star in the sky, a person at any point on Earth will see a satellite in this orbit stationary with respect to its position.

Note: Every geostationary orbit is a geosynchronous orbit but not vice-versa. A satellite will be geostationary if the revolution of a satellite is towards west to east, with respect to the rotation of Earth.

### 6.7.9 Geosynchronous Transfer Orbit (GTO)

Geostationary Transfer Orbit (GTO) is an elliptical orbit, with an apogee (high point) of 35,784 kilometres and an inclination roughly equal to the latitude of the launch site, into which a spacecraft is initially placed before being transferred to a geosynchronous or geostationary orbit (**Figure 6.4**). [**Apogee:** This is a point in the orbit of a body (especially moon), or of a man-made satellite, at the farthest distance from the Earth].

## 6.8 SATELLITE LAUNCHING SYSTEMS

Since the eastern side of the east-coast has a water body, the satellite launching stations are generally located on the east-coast and as close as possible to the equator; for instance, Cape Canaveral on the south-east coast of Florida of the USA, northeast coast of French Guyana in South America (**Table 6.2**). The launch vehicle moves from west to east, same as the direction of Earth's rotation, so it is easy to up-thrust since Earth's rotation helps the satellite to launch it in the same direction.

**TABLE 6.2 Some Important Rocket Launching Station of the World**

| Rocket Launching Station | Country |
|---|---|
| Al Anbar | Iraq |
| Baikonur | Kazakhstan (Formerly in the USSR) |
| Cape Canaveral | Florida, the USA |
| Emamshahr | Iran |
| Edwards Air Force Base | California, the USA |
| Kennedy Space Centre | Merrit Island, Florida, the USA |
| Kourou | French Guiana, (It is a French territory in South America) |
| Kapustin Yar | Russia |
| Jiquan Space Launch Centre | China |
| Plesetsk Cosmodrome | Russia |
| Palmachim Air Base | Israel |
| Sriharikota | Andhra Pradesh, India |
| Uchinoura Space Centre | Kagoshima, Japan |
| Woomera | Australia |

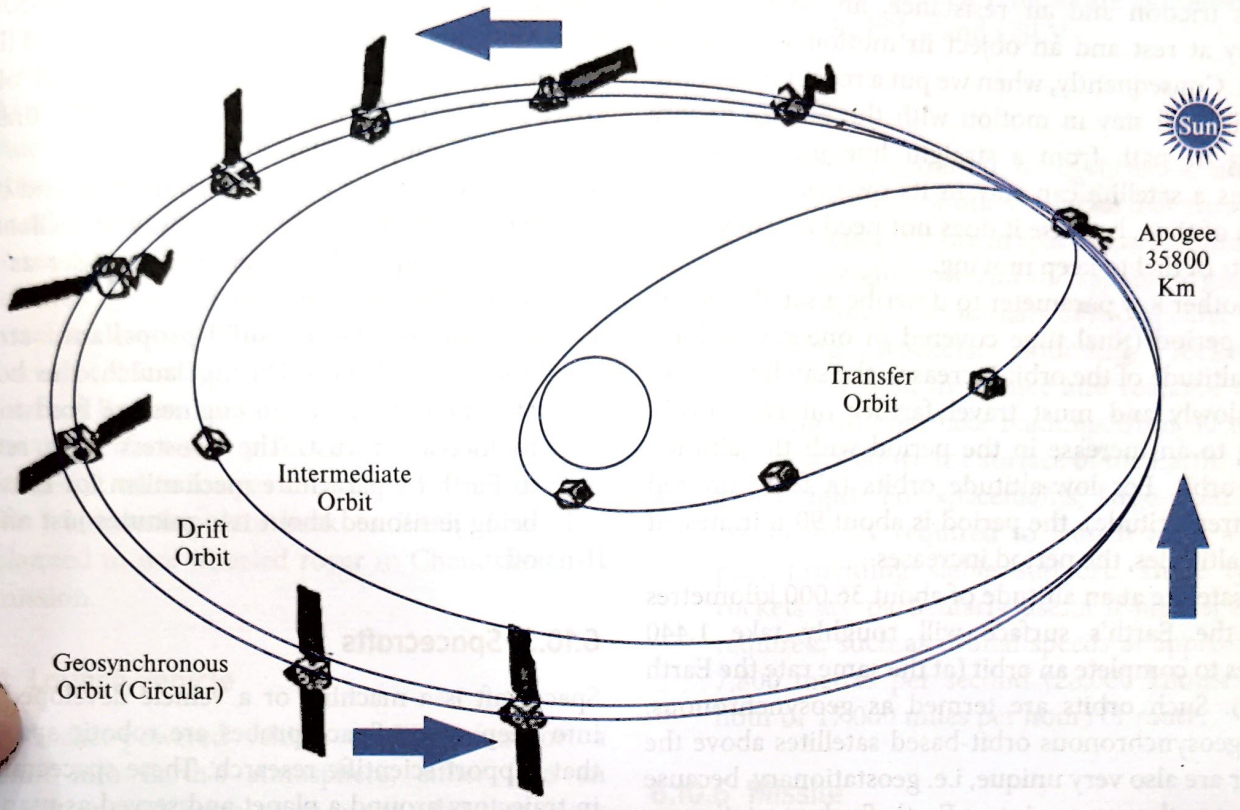



**Figure 6.4**
Satellites follow different orbits to reach specific destinations – Transfer orbit, Intermediate orbit, Drift orbit and Geosynchronous orbit

## 6.9 WHY SATELLITES DO NOT FALL DOWN?

Satellite do not fall down to the surface of Earth even though a satellite is under the attraction of Earth (within Earth's orbit). It is defined on the basis of the orbital speed of satellites.

Because of Earth's gravity, everything thrown upwards or straight eventually comes down or falls down. However, in case of a satellite launched using a rocket, after reaching into the space, it does not fall down due to balance of centrifugal forces and Earth's gravity. This outward force (the centrifugal force) becomes greater, the faster the object swings. A certain 'orbital speed' is required to balance the centrifugal force of the satellite due to its motion around the Earth and pull of gravity so that the satellite is in proper orbit.

If a satellite is going farther from Earth, the weaker the gravity and hence, to balance the centrifugal forces and gravity, orbital speed of satellite will decrease (**Table 6.3**). The speed of a satellite in orbit is independent of the mass of the satellite.

**TABLE 6.3 Selected values for the orbital speed, orbital period and altitude of satellites in circular orbits**

| Altitude (km) | Orbital Speed (km/s) | Orbital Period (minutes) |
|---|---|---|
| 200 | 7.8 | 88.3 |
| 500 | 7.6 | 94.4 |
| 1,000 | 7.4 | 104.9 |
| 5,000 | 5.9 | 201.1 |
| 10,000 | 4.9 | 347.4 |
| 20,200 (Semi-synchronous) | 3.9 | 718.3 (12 hours) |
| 35,800 (Geosynchronous) | 3.1 | 1436.2 (24 hours) |

Satellites follow their own orbits as per Newton's first law of motion (Law of Inertia). According to Newton's first law of motion, in the absence of forces

such as friction and air resistance, an object at rest will stay at rest and an object in motion will stay in motion. Consequently, when we put a rocket in motion, a satellite will stay in motion with the Earth's gravity bending its path from a straight line into an orbit. It means a satellite can stay in its own orbit for long periods of time, because it does not need to carry large amounts of fuel to keep moving.

Another key parameter to describe a satellite is the orbital period (total time covered in one revolution). As the altitude of the orbit increases, the satellite moves more slowly and must travel farther on each orbit, leading to an increase in the period with the altitude of the orbit. For low-altitude orbits (a few hundred kilometres altitude), the period is about 90 minutes; at higher altitudes, the period increases.

A satellite at an altitude of about 36,000 kilometres above the Earth's surface will roughly take 1,440 minutes to complete an orbit (at the same rate the Earth rotates). Such orbits are termed as geosynchronous. Those geosynchronous orbit-based satellites above the equator are also very unique, i.e. geostationary, because it stays over the same point on Earth. Such geostationary orbits have multiple uses.

## 6.10 BASIC CONCEPTS

### 6.10.1 Satellite

A satellite may be natural (moon) or human-made (machine) that orbits a planet or a star. For example, a moon is a satellite because it orbits Earth, similarly, Earth is a satellite as it orbits the Sun. An artificial 'satellite' refers to a machine that is launched into space and moves around Earth or other object in space. Satellites have numerous applications in the study of planets, like weather forecasting, study of galaxy, etc., to understand the solar system and universe better. All communication and information technology is also based on satellites. More than 20 satellites are required in a Global Positioning System (GPS). Soviet Union based Sputnik-1 was the first satellite in space launched in 1957.

### 6.10.2 Space Shuttle

Space Shuttle is a reusable rocket-launched vehicle that is designed to go into Earth's orbit. It is useful to send astronauts/cosmonauts and cargo to space. National Aeronautics and Space Administration (NASA) has developed the first space shuttle, formally called the STS (Space Transportation System), which lifted off into space first on 12 April 1981. A space shuttle consists of three major components:

- **Winged orbiter** – It carries both crew and cargo.
- **An external tank** – It contains propellant (fuel such as liquid hydrogen and oxidiser as liquid oxygen for rocket engines).
- **A pair of large, solid-propellant, strap-on booster rockets** – During launch, the boosters and the orbiter's main engines are fired together to increase thrust. The boosters were returned to Earth by parachute mechanism for reuse after being jettisoned about two minutes just after lift-off.

### 6.10.3 Spacecrafts

Spacecraft is a machine or a vehicle developed to go into deep space. Space probes are robotic spacecrafts that support scientific research. These spacecrafts stay in trajectory around a planet and served as man-made satellites. Only few interstellar probes, such as *Voyager 1 and 2, New Horizons and Pioneer 10 and 11*, are on trajectories that leave the solar system.

*Type of Spacecrafts*

- **Orbiter Spacecraft:** This type of spacecraft is designed to go to distant planets or moon and enter their own orbit. They have high temperature resistance and power-storage capacity. For power generation, it is equipped with solar array (a group of solar panel). Examples: Galileo, Magellan and Mars Global Surveyor.
- **Manned Spacecraft:** It is used to carry astronauts into space. It requires life-support systems with crew compartment. They are designed to use either one time (like Soyuz) or reusable (like the space shuttle).
- **Flyby Spacecraft:** Flyby spacecrafts follow a continuous trajectory path to a target object. It is never sent into an orbit. Examples: Voyagers 1 and 2 and Pioneers 10 and 11.
- **Atmospheric Probe:** It is a small-sized instrumented craft that separates from the main spacecraft when it comes close to a planet. It involves the study of gaseous atmosphere. It

is equipped with an aero shell to protect this probe during atmospheric entry and a parachute mechanism is adopted to slow its decent.

- **Atmospheric Balloon Package:** It is used to study wind circulation patterns in a planet's atmosphere.
- **Lander Spacecraft:** Lander spacecraft is designed to reach the surface of a planet or moon as landing technology on the surface with longer survivability. It telemeters data back to the Earth. Examples: Surveyor, Mars Pathfinder, etc.
- **Surface Rover:** They mostly have wheels to rove on the surface of a planet or on other planetary bodies. It takes images and also does soil analysis for telemetering data back to Earth. India has planned to use wheeled rover in Chandrayaan-II mission.

### 6.10.4 Launch Vehicle

It is a rocket-powered vehicle used to transport a spacecraft into Earth's atmosphere, either into an inner orbit around Earth or an outer orbit into some other destination in outer space. Launch vehicles are being used to send unmanned space probes, manned spacecrafts and various satellites into space since the 1950s. India's used launch vehicles are as follows: RLV-TD, SLV, ASLV, PSLV and GSLV.

### 6.10.5 Rocket

Rocket engine is required to upthrust a missile, a spacecraft, an aircraft or other vehicles that are sent into space. Its efficiency is more in space than in atmosphere. They are lightweight, powerful and capable of generating large accelerations. Various uses of rockets are:

- **Sounding Rockets:** Sounding rockets are commonly used in science and research to carry instruments that take readings from 50 to 1,500 kilometres above the surface of the Earth.
- **Spaceflight:** For spaceflights, large-sized rockets are normally required to launch from a launch pad, providing stable support. These types of rockets are particularly useful if high speeds are required, such as orbital speeds at approximately 7,800 metres per second (28,000 kilometres per hour or 17,000 miles per hour) or more.

### 6.10.6 Missile

A **missile** is a self-propelled precision-guided system. They **consist of four components:** targeting or missile guidance system, flight system, engine and warhead.

## 7.1 EXPERIMENTAL SATELLITES

Since its inception many years ago, Indian Space Research Organisation (ISRO) has launched a few experimental satellites for the purposes of remote sensing, orbital controls, atmospheric studies, etc. **Table 7.1** shows the list of such satellites launched by ISRO.

YouthSat is an Indo-Russian atmospheric satellite, built and developed by graduate, postgraduate and research scholars. This satellite is among the few satellites of ISRO that are built by students.

## 7.2 EARTH OBSERVATION SATELLITES

Besides the experimental satellites, ISRO has sent many missions with the objective of Earth observation, focussed mainly on climate, environment, disaster management, etc. At present, ISRO's IRS, i.e., Indian Remote Sensing system has one of the biggest satellite constellations that are presently operational. Starting from IRS 1A, HysIS, (Hyper spectral imaging satellite), ISRO launched its ScatSat 1 satellite, which is specifically launched for climate and environmental purposes. These satellites supply necessary data in a spectral, spatial and temporal resolution for global usage. In several applications covering agriculture, water resources, urban planning, rural development, forestry, ocean resources, mineral prospecting, environment and disaster management, such data is of immense use. Following is the most important observation mission by ISRO.

### 7.2.1 NISAR: NASA-ISRO Synthetic Aperture Radar

In April 2012, India launched its first indigenous radar imaging satellite. With this satellite, India can easily observe visibility during both day and night and work in all types of weather and it will take images of Earth properly. Defining the roles and responsibilities of ISRO and NASA, a memorandum was signed between the two agencies in September 2014, by Barak Obama and Indian PM Narendra Modi (during Modi's visit to USA).

#### 7.2.1.1 NISAR Background

The first Joint Steering Group (JSG) meeting of NISAR was held on 21 July 2015.

**NASA Contribution:** In this joint mission, JPL/NASA will be responsible for the designing and development of L-band SAR, GPS system and data recorder.

**ISRO Contribution:** ISRO will be responsible for the designing and development of S-band SAR, spacecraft bus, data transmission system, spacecraft integration and testing, and launch using GSLV and on-orbit operations.

**TABLE 7.1** Different Experimental Satellite Launched by India

| Satellite Name | Launch Date | Launch Mass | Launch Vehicle | Orbit Type | Application | Remarks |
|---|---|---|---|---|---|---|
| INS -2D | Feb 14, 2022 | | PSLV-C52/EOS-04 Mission | | Experimental | |
| INS-1C | Jan 12, 2018 | | PSLV-C40/Cartosat-2 Series Satellite Mission | SSPO | Experimental | |
| INS-1A | Feb 15, 2017 | 8.4 kg | PSLV-C37/Cartosat-2 Series Satellite | SSPO | Experimental | |
| INS-1B | Feb 15, 2017 | 9.7 kg | PSLV-C37/Cartosat-2 Series Satellite | SSPO | Experimental | |
| YOUTHSAT | Apr 20, 2011 | 92 kg | PSLV-C16/RESOURCESAT-2 | SSPO | Student Satellite | |
| APPLE | Jun 19, 1981 | 670 kg | Ariane-1(V-3) | GSO | Communication, Experimental | |
| Rohini Satellite RS-1 | Jul 18, 1980 | 35 kg | SLV-3E2 | | | |
| Rohini Technology Payload (RTP) | Aug 10, 1979 | 35 kg | SLV-3E1 | | | Launch Unsuccessful |
| Aryabhata | Apr 19, 1975 | 360 kg | C-1 Intercosmos | | Experimental | |

### 7.2.1.2 Launch of NISAR

The satellite will be launched from India in **2024 by GSLV Mark-II** launch vehicle of ISRO from Satish Dhawan Space Centre in Sriharikota, India. NISAR will be a future Earth observation satellite.

- **Orbit: Sun-synchronous/dawn-dusk orbit**
- **Altitude: 747 km**
- **Inclination angle = 98.4°**
- L-band (1.25 GHz, 24 cm wavelength) polarimetric SAR, to be produced by NASA
- S-band (3.20 GHz, 9.3 cm wavelength) polarimetric SAR, to be produced by ISRO
- **It will scan the globe every 12 days** (repeat cycle of 12 days) over the course of its **three-year mission** of imaging the **Earth's land, ice sheets and sea ice** to give an 'unprecedented' view of the planet.
- It will detect **movements of the planet's surface as small as 0.4 inches over areas** about half the size of a tennis court.
- NASA will provide one of the radars for the satellite, a high-rate communication sub-system for science data, GPS receivers and a pay-load data subsystem.
- ISRO will provide the spacecraft bus, the second type of radar (called the S-band radar), the launch vehicle and associated launch services.

**SYNTHETIC APERTURE RADAR (SAR)**

The name NISAR is shortened form of **NASA-ISRO-SAR.** SAR here refers to **the synthetic aperture radar** that NASA will use to measure changes in the surface of the Earth.

- Essentially, SAR refers to a technique for producing high-resolution images.
- Because of its precision, the radar can penetrate clouds and darkness, which means that it can collect data day and night in any weather.

A **synthetic aperture radar (SAR)** is an active sensor that first **transmits microwave signals** and then receives back the signals that are returned, or back scattered, from the Earth's surface. The instrument measures distances between the sensor and the point on the Earth's surface where the signal is backscattered.

SAR is a **coherent, mostly airborne or space borne, side looking radar system** which utilises the flight path of the platform to simulate an extremely large antenna, and that **generates high-resolution remote sensing imagery.**

- NISAR will be equipped with the largest reflector antenna ever launched by NASA and its primary goals include tracking subtle changes in the Earth's surface, spotting warning signs, helping to monitor groundwater supplies and tracking the rate at which ice sheets are melting.

## 7.3 INDIAN REMOTE SENSING SATELLITE (IRS SYSTEM)

India started its own Remote Sensing (IRS) satellite programme after successful tests of the Bhaskara 1 and Bhaskara 2 satellites. Further, National Natural Resources Management System (NNRMS) was established for the provision of active remote sensing data services. The Department of Space (DoS) was deemed the nodal agency. This data is received and distributed to various countries seeking privilege. The sectors of urban and infrastructural planning have seen a big push towards prosperity due to the applications of new high-resolution satellites and high performance applications.

Indian nomenclature is a bit straight forward. For instance, initially they used to name the satellites as 1A, 1B, so on. Later, the names were based on the area of application of the satellites (CartoSat, OceanSat).

### 7.3.1 Applications of Indian Remote Sensing Satellites

Indian Remote Sensing satellites are used for various applications of resources survey and management. Followings are the list of applications:

(a) In Space Based Inputs for Decentralised Planning (SIS-DP)
(b) In National Urban Information System (NUIS)
(c) In ISRO based Disaster Management Support Programme (ISRO-DMSP)
(d) In Hydro-geomorphological maps for locating underground water resources
(e) In irrigation command area status monitoring
(f) Observation of snow-melt run-off estimates for planning water use in downstream projects
(g) In the land use and land cover mapping
(h) In urban planning
(i) In forest survey
(j) In the characterisations of biodiversity

(k) In the observation of crop area cover and production estimation of major crops
(l) In the drought monitoring and assessment
(m) In flood risk zone mapping and flood damage assessment
(n) In wetland mapping
(o) In environmental impact analysis
(p) In mineral prospecting
(q) In coastal studies
(r) In 1992, Integrated Mission for Sustainable Development initiated in 174 districts for generating locale-specific prescriptions for integrated land and water resources development

All the data thus received from the satellites gets stored in Indian data centres and is available for public use *via* National Remote Sensing Centre (NRSC) data centres, and ISRO's Bhuvan Geoportal as open domain.

The Indian Institute of Remote Sensing and Centre of Space Science and Technology Education in Asia and the Pacific, both located in Dehradun, play an important role in the capacity-building programme of ISRO.

### 7.3.2 Satellite Data Acquisition and Processing

**National Remote Sensing Centre (NRSC), Hyderabad,** is the nodal agency for achieving, receipting, handling and disseminating of remote sensing data in the whole country. The agency obtains and operates data from all the country's remote sensing satellites such as Resourcesat-1, IRS-1D, Oceansat-1, Cartosat-1, Cartosat-2 and foreign as well as Technology Experiment Satellites such as Terra, ERS and NOAA (**Table 7.2**).

Source: https://www.isro.gov.in (last accessed in June 2023)

### COMPARATIVE STUDY OF EARTH OBSERVATION SATELLITES AND REMOTE SENSING SATELLITES

Without being in direct contact with them, remote sensing technique is used for observing and analysing objects from a distance. During the Earth study, the term Earth observation is often used, which meant, the collected information from Earth by the observing satellites.

The most widespread remote sensing systems measure reflected visible light, but the electromagnetic radiation can also be measured by them which is invisible to the human eye, e.g. infrared (IR), ultraviolet (UV) or microwave radiation. The reality is that the measurement done by satellites in different spectral wavelengths is used for acquiring information about the features and properties of the objects under study.

Some meteorological satellites are placed at around 36000 km above the equator, whereas other Earth resource and meteorological satellites circle Earth at about 800 km altitude. Some satellites view Earth infrequently with very high spatial resolution, even less than a metre, whereas other satellites image Earth frequently with low spatial detail.

Extensive range of phenomena and features can be monitored with the usage of Earth observation data, for example, phenology, vegetation biomass, land and sea surface temperature, ocean salinity, water quality and manifold, etc. Thus, Earth observation data present a powerful tool for the observance of processes which are human and nature induced, such as land cover changes, biogeochemical cycles, climate change and climatic variability.

## 7.4 INDIAN SATELLITE (INSAT)/ GEOSTATIONARY SATELLITE (GSAT)

ISRO initiated all-purpose geostationary series of satellites which accords to be the largest domestic communications system of the Asia Pacific, which is named as INSAT or Indian National Satellite System. It serves the objectives of broadcasting, meteorology and telecommunications, and search and rescue operations. It is a combined initiative of the **India Meteorological Department, All India Radio (AIR), Department of Space (DoS), Department of Telecommunications (DoT) and Doordarshan.** It includes various transponders for the various bands available for television and communications purposes serving the country. These satellites have the capability to pick up distress signals for undertaking operations of search and rescue operations in the regions of Indian Ocean and the South Asia.

**Established in 1983 with commissioning of INSAT-1B,** it initiated a major revolution in India's communication sector and sustained the same later. GSAT-17 joins the constellation of INSAT System consisting of 15 operational satellites, namely – INSAT-3A, 3C, 4A, 4B, 4CR and GSAT-6, 7, 8, 9, 10, 12, 14, 15, 16 and 18.

The INSAT system with more than 200 transponders in the C, Extended C and Ku-bands provides services to telecommunications, television broadcasting, satellite news gathering, societal applications, weather forecasting, disaster warning and search and rescue operations.

Earlier, the name of the satellite was INSAT but now GSAT is used. INSAT 1 and 2 series (except INSAT 2E) have expired but many of INSAT 3 and 4 series satellites are functional. List of communication satellites are mentioned in **Table 7.3**.

Following is the most important GSAT satellite.

### *GSAT-9/SAARC Satellite Launched under 'Neighbours First Policy'*

It is also popular with the name of SAARC Satellite or South Asian Satellite launched by India. With the launch of GSAT-9, India fulfilled the promise of 2014 SAARC Summit when Prime Minister Narendra Modi forayed into space diplomacy to strengthen the 'neighbours first policy'. This was launched successfully on 5 May 2017 by **GSLV-F09** to cover South Asian countries.

Its lift off mass was 2,230 kilograms and it was cuboidal in shape. **GSAT-9** carries communication transponders operating in Ku-band with an expenditure of ₹235 crores. It strengthened cooperation in disaster management and telecommunications among South Asian countries, namely Bangladesh, Sri Lanka, Bhutan, Nepal, Maldives and Afghanistan but Pakistan was not opted. Working on the Ku-band, it will provide the countries with capability in the field of tele-education, tele-medicine, broadcasting, Direct-to-Home services (DTH) and VSAT capacity with their linking services. All the countries will have at least a transponder through which they can telecast their own programming. The countries will build their own ground-level infrastructure. All the other costs for the launch of the satellite has been borne by India.

## 7.5 EXCEEDSAT-1 (INDIA'S 1ST PRIVATE SATELLITE)

With the ExseedSat-1 launch, **it has become the country's first privately-funded start-up in successfully sending a satellite to space.**

- It was launched by **Space X** into space along with 63 other satellites from 17 countries.
- The small communication satellite which weighs a kg with twice the Rubik's cube (10 cm × 10 cm × 10 cm) size is formed of aluminium alloy.
- The satellite looks to serve the amateur radio community.
- The satellite having a **five years** lifespan will allow nation for receiving signals on 145.9 MHz frequency through a TV tuner.

The satellite would provide a big boost to private radio operators and help in coordinating messages among them and help the country in time of disaster.

## 7.6 LAUNCH VEHICLE TECHNOLOGY

### *Launch Vehicles*

The combination of thrusters and boosters that help in carrying the spacecraft to space is known as Launch Vehicles. Achieving a high accuracy in placing the satellites to their designated orbits requires adequate combination of accuracy, power, efficiency and immense to-the-point planning. ISRO's launch vehicle programme is the guiding arm of all the development of launch vehicles, which has various centres as per their speciality. **The designing and development of launch vehicles is taken up in Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram.** The liquid and cryogenic stages for these launch vehicles are developed at Liquid Propulsion Systems Centre, Valiamala, and ISRO Propulsion Complex, Mahendragiri. Satish Dhawan Space Centre (earlier known as SHAR), is the space port of India, responsible for integration of launchers. It houses two operational launch pads from where all flights are launched and a third launch pad is under development.

### *Sounding Rocket*

One- or two-stage solid propellant rockets used for the investigation of upper atmosphere and space research are called Sounding Rockets. These are a cheap platform for testing new prototypes that could later go in a launch vehicle or a satellite. **The launch of the first sounding rocket from Thumba near Thiruvananthapuram, Kerala on 21 November 1963, marked the beginning of the Indian Space Programme. It was imported from Russia.**

India used to import these rockets from Russia and France. The Russian **M-100** had a capability to carry 70 kilograms to an altitude of 85 kilometres. The **Centaure (France)** could carry a payload of about 30 kilograms to at least 150 kilometres. From 1965, ISRO started launching its own sounding rockets and in 1975, all these activities were consolidated under one roof and came to be known as Rohini Sounding Rocket (RSR) programme.

India has developed **five generations of launch-vehicle technologies:**

- **First Generation:** SLV (Satellite Launch Vehicle)
- **Second Generation:** ASLV (Augmented Satellite Launch Vehicle)
- **Third Generation:** PSLV (Polar Satellite Launch Vehicle)
- **Fourth Generation:** GSLV (Geostationary Satellite Launch Vehicle): GSLV MK I and GSLV MK II
- **Fifth Generation:** GSLV MK III / LVM III

### 7.6.1 First Generation: Satellite Launch Vehicle

Satellite Launch Vehicle-3 (see **Table 7.4**) was four-stage launch vehicle, consisting of all solid, nature of propellant, capable of placing **40 kilograms class payloads in Low Earth Orbit (LEO) at a distance of 400 kilometres.** SLV-3, a first in this generation, was **successfully launched on 18 July 1980 from Sriharikota High Altitude Range (SHAR). It successfully placed Rohini satellite (RS-1)** in its orbit. **This project was headed by Dr. APJ Abdul Kalam.** Now SLV is not in use.

**TABLE 7.4** Different SLV used by India

| Launcher | Launch Date | Payload |
|---|---|---|
| SLV-3 | 17 April 1983 | Rohini Satellite RS-D2 |
| SLV-3D1 | 31 May 1981 | Rohini Satellite RS-D1 |
| SLV-3E2 | 18 July 1980 | Rohini Satellite RS-1 |
| SLV-3E1 | 10 August 1979 | Rohini Technology Payload (RTP) |

### 7.6.2 Second Generation: Augmented Satellite Launch Vehicle (ASLV)

The ASLV Programme (see **Table 7.5**) was designed to augment the payload capacity to 150 kilograms in LEO. It was five-stage launch vehicle technology, in all had solid propellant. Under the ASLV programme, four developmental flights were conducted. It is now retired.

**TABLE 7.5** Different ASLV used by India

| Launcher | Launch Date | Payload |
|---|---|---|
| ASLV-D4 | 05 May 1994 | SROSS-C2 |
| ASLV-D3 | 20 May 1992 | SROSS-C |
| ASLV-D2 | 13 July 1988 | SROSS-2 |
| ASLV-D1 | 24 March 1987 | SROSS-1 |

### 7.6.3 Third Generation: Polar Satellite Launch Vehicle (PSLV)

India's one of the most reliable and the most popular launch vehicle (**Table 7.6**) has been in service for over twenty years, and has been the reason for some historic missions like Mars Orbiter Mission (MOM) and Indian Regional Navigation Satellite System (IRNSS).

It was a four-stage multi propellant launcher that has a height of 44 metres and a lift-off weight of 320 tonnes (PSLV XL) [First stage – **Solid (HTPB – Hydroxyl terminated polybutadiene)**, Second stage – **Liquid (UDMH – Unsymmetrical Dimethyl Hydrazine)**, Third stage – **Solid (HTPB)**, Fourth stage – **Liquid (MMH – Monomethyl hydrazine + MON – Mixed oxide of Nitrogen]**. Propellant is a mixture of fuel and oxidiser. Oxidiser is necessary for the burning of fuel. $N_2O_4$ (Nitrogen Tetra Oxide) is used as an oxidiser in propellant technology. PSLV has three variants – PSLV G, PSLV CA and PSLV XL. It is the "**workhorse of ISRO**".

It is designed and developed at VSSC, Thiruvananthapuram. Most of the development is done in Thiruvananthapuram. ISRO's Inertial Systems Unit (IISU) develops the inertial systems. Liquid Propulsion Systems Centre (LPSC) looks after the propulsion systems for the second and fourth stages, and also takes care of the reaction control systems. The solid propellant

motors are managed by Satish Dhawan Space Centre (HAR), which also carries out the launch operations.

**Payload to SSPO (Sun Synchronous Polar Orbit): 1,750 kg**
PSLV earned its title 'the Workhorse of ISRO' through consistently delivering various satellites to Low Earth Orbits, particularly the IRS series of satellites. It can take up to 1,750 kg of payload to Sun Synchronous Polar Orbits of 600 km altitude.

**Payload to GTO: 1,425 kg**
Due to its unmatched reliability, PSLV has also been used to launch various satellites into Geosynchronous and Geostationary orbits, like satellites from the IRNSS constellation.

### 7.6.4 Fourth Generation: Geosynchronous Satellite Launch Vehicle (GSLV)

GSLV was developed by ISRO for a capability to launch geosynchronous satellites into geostationary orbits. This made India less dependent on other countries for their launch vehicles. The three variants include **GSLV Mark I (a)** with a capability of 1,500 kilograms, **GSLV Mark I (b)** with a capability of 1,900 kilograms and **GSLV Mark II** that uses Indian Cryogenic Engine, developed by Liquid Propulsion System Centre (LPSC), and is capable of launching 2,500 kilograms of payload to GTO (Geostationary Transfer Orbit) and up to 5,000 kilograms of payload to LEO. Different GSLVs launched by India are given in **Table 7.7**.

**TABLE 7.7** Different GSLV launched by India

| Launch Vehicle/Satellite | Launch Date | Launcher Type | Orbit | Payload | Remarks |
|---|---|---|---|---|---|
| GSLV-F12/NVS-01 Mission | May 29, 2023 | GSLV | GTO | NVS-01 | |
| GSLV-F10 / EOS-03 | Aug 12, 2021 | GSLV | GTO | EOS-03 | Mission unsuccessful |
| GSLV-F11/GSAT-7A Mission | Dec 19, 2018 | GSLV | | GSAT-7A | |
| GSLV-F08/GSAT-6A Mission | Mar 29, 2018 | GSLV | GSO | GSAT-6A | |
| GSLV-F09/GSAT-9 | May 5, 2017 | GSLV | GSO | GSAT-9 | |
| GSLV-F05/INSAT-3DR | Sep 8, 2016 | GSLV-MK-II | GTO | INSAT-3DR | |
| GSLV-D6 | Aug 27, 2015 | GSLV-MK-II | GTO | GSAT-6 | |
| GSLV-D5/GSAT-14 | Jan 5, 2014 | GSLV-MK-II | GTO | GSAT-14 | |
| GSLV-F06/GSAT-5P | Dec 25, 2010 | GSLV-MK-II | GTO | GSAT-5P | Mission Unsuccessful |
| GSLV-D3/GSAT-4 | Apr 15, 2010 | GSLV-MK-II | | GSAT-4 | Mission Unsuccessful |
| GSLV-F04/INSAT-4CR | Sep 2, 2007 | GSLV-MK-II | GTO | INSAT-4CR | |
| GSLV-F02/INSAT-4C | Jul 10, 2006 | GSLV-MK-II | GTO | INSAT-4C | Mission Unsuccessful |
| GSLV-F01/EDUSAT(GSAT-3) | Sep 20, 2004 | GSLV-MK-II | GTO | EDUSAT | |
| GSLV-D2/GSAT-2 | May 8, 2003 | GSLV-MK-II | GTO | GSAT-2 | |
| GSLV-D1/GSAT-1 | Apr 18, 2001 | GSLV-MK-II | GTO | GSAT-1 | |

*Source:* https://www.isro.gov.in (last accessed in June 2023)

GSLV is a three-stage launch vehicle, where the first two stages are similar to PSLV with same solid and liquid natures of fuel but the third stage is completely different, i.e., **cryogenic stage**. Earlier, India used Russian-made cryogenic engine. However, now, ISRO developed its own cryogenic engine in LSPC, Mahendragiri, Tamil Nadu. On 6 January 2014, India used the first cryogenic upper stage engine, those successfully used in GSLV-D5.

**First Stage** It is made of maraging steel and uses solid propellants.

**Second Stage** Vikas engine powers up this stage and UDMH is used as fuel along with Nitrogen Tetroxide ($N_2O_4$) as oxidiser.

**Third Stage** driven by an indigenous cryogenic engine, uses liquid hydrogen and liquid oxygen in separate chambers interconnected by an inter-stage.

**Cryogenic Engine** Cryogenic is a low-temperature based technology. In this propellant system, $LH_2$ (Liquid Hydrogen) is used as a fuel and $LO_2$ (Liquid Oxygen) as an oxidiser. Oxygen liquefies at −183 °C and Hydrogen at −253 °C.

At such low temperatures, the propellants are to be pumped using turbo pumps running at around 40,000 rpm. It also entails complex ground support systems like propellant storage and filling systems, cryo-engine and stage test facilities, transportation and handling of cryo fluids and related safety aspects. As compared to solid and liquid propellant rocket stages, a cryogenic rocket stage is more efficient and provides more thrust for the burning of propellant. Specific impulse (a measure of the efficiency) achievable with cryogenic propellants (liquid Hydrogen and liquid Oxygen) is much higher compared to Earth-based storable liquid and solid propellants, thus it is advantageous in the form of substantial payload.

### CRYOGENIC TECHNOLOGY

Cryogenic technology is the development of useful applications based on cryogenic science, which is the study of temperatures below −150 °C, how to produce such low temperatures and the behaviour of materials at those temperatures. Cryogenic is a Greek word and means **'the production of freezing cold'.**

Various areas of cryogenic technology/science are:

- **Cryobiology:** It deals with the study of the effects of low temperatures on organisms, generally for the purpose of achieving cryopreservation.
- **Cryonics:** The emerging medical technology of cryopreserving humans and animals with the intention of future revival.
- **Cryoelectronics:** Research of super conductivity at very low temperatures.
- **Cryotrocins:** It is the real application of Cryoelectronics.

#### Gases Used and Storage

Liquid nitrogen and liquid helium are used in cryogenic applications. Most often, liquid nitrogen is used in cryogenics. Liquid helium is also used and allows for the lowest attainable temperatures to be reached. A special type of container is used to keep these liquids known as Dewar flasks.

#### Applications

1. **Superconductivity:** Cryogenic materials such as liquid nitrogen are useful for producing the temperatures necessary for superconductivity applications.
2. **Cryogenic fuels:** Largely, liquid hydrogen has been used as rocket fuel. Liquid oxygen is used as an oxidiser of hydrogen, but oxygen is not strictly called as a fuel.
3. **Cryostorage:** Cryogenic gases are used in transportation of large masses of frozen food. When huge quantity of food must be transported to regions like war fields, earthquake-hit regions, etc., they must be stored for a long time. So cryogenic food freezing is used.
4. **Cryocooling:** Use of cryogenic gases for cooling (heat exchange) purposes in industrial applications, such as electrical cables.
5. **Magnetic Resonance Imaging:** It is a technique of imaging objects where a strong magnetic field is required that is generated by electromagnets. Elevated field strengths can be addressed by using superconducting magnets. Normally, liquid helium is used to cool the superconducting coils.
6. **Cryogenic processing:** This was developed during World War II when scientists found that metals frozen to low temperatures exhibited more resistance to wear.
7. **Cryomilling:** Some soft or elastic materials turn to hard and brittle at very low temperatures, which make cryogenic milling (cryomilling) an option for some materials that cannot easily be milled at higher temperatures.

## 7.6.5 Fifth Generation: GSLV MK- III

GSLV Mk-III is a three-stage heavy lift launch vehicle developed by ISRO. GSLV Mk-III is intended for carrying **4 ton class of satellites into Geosynchronous Transfer Orbit** (GTO) or about **8 tons to Low Earth Orbit** (LEO), which being twice the GSLV Mk-II capability. **Table 7.8** lists various GSLV Mk-III launched.

**TABLE 7.8 List of GSLV Mk-III**

| Title | Launch Date | Launcher Type | Payload |
|---|---|---|---|
| LVM3 M4 / Chandrayaan-3 Moon Mission | July 14, 2023 | LVM3 | Chandrayaan-3 |
| LVM3 M3 / OneWeb India-2 Mission | Mar 26, 2023 | LVM3 | OneWeb Gen-1 |
| LVM3 M2 / OneWeb India-1 Mission | Oct 23, 2022 | LVM3 | OneWeb Gen-1 |
| GSLV-Mk-III – M1/ Chandrayaan-2 Mission | Jul 22, 2019 | Payload | Chandrayaan-2 |
| GSLV Mk-III-D2/ GSAT-29 Mission | Nov 14, 2018 | GSLV-MK-III | GSAT-29 |
| GSLV Mk-III-D1/ GSAT-19 Mission | Jun 05, 2017 | GSLV-MK-III | GSAT-19 |
| LVM-3/CARE Mission | Dec 18, 2014 | GSLV-MK-III | Crew module Atmospheric Reentry Experiment (CARE) |

*Source:* https://www.isro.gov.in (last accessed in July 2023)

(I) **First Experimental Flight of GSLV MK-III:** The first experimental LVM3 flight, the LVM3-X/ CARE mission took off on 18 December 2014 from Sriharikota and successfully tested the flight atmospheric phase. In this flight, the **Crew Experiment module Atmospheric Re-entry** was also carried out. The module re-entered, as per the planning, deployed its parachutes and splashed down in the Bay of Bengal.

(II) **First developmental flight of GSLV Mk-III: GSLV MK-III D1** – successfully positioned GSAT-19 satellite on 5 June 2017 to a GTO from SDSC, Sriharikota.

(III) **Second developmental flight of GSLV Mk-III: GSLV Mk-III D2** – the second developmental flight of GSLV Mk-III successfully launched GSAT-29, a high throughput communication satellite in Geosynchronous transfer orbit, on 14 November 2018 from SDSC, Sriharikota.

(IV) **GSLV MkIII-M1,** successfully injected **Chandrayaan-2, India's second Lunar Mission,** into Earth Parking Orbit on July 22, 2019 from SDSC SHAR, Sriharikota.

(V) **LVM3-M2/OneWeb India-1 Mission:** The LVM3-M2 mission is a dedicated commercial mission for a foreign customer OneWeb, through NSIL. It is the first multi-satellite mission with 36 OneWeb Satellites to the LEO as the heaviest payload mass of 5,796 kg of LVM3 till date.

***Salient Features of the Mission***

- First commercial mission of LVM3
- First multi-satellite mission with 36 OneWeb Satellites onboard
- First launch of LVM3 to LEO
- First Indian rocket with six ton payload
- First NSIL mission with LVM3
- First OneWeb mission with NSIL/DoS

(VI) **LVM3 M3/ OneWeb India-2 Mission:** LVM3 M3/ OneWeb as part of India-2 Mission, in its sixth consecutive flight successfully placed 36 satellites belonging to the OneWeb Group Company in their intended 450 km circular orbit with an inclination of 87.4 degrees. The vehicle took off with a total payload of 5,805 kg from the second launch pad at SDSC-SHAR, Sriharikota.

Note: **OneWeb Ltd** is a **global communication network** powered from space, **enabling internet connectivity for governments and businesses. India's Bharti Enterprises is a major investor and shareholder in OneWeb.**

**VIKAS ENGINES**

These are **liquid fuelled rocket engines** developed by the **Liquid Propulsion Systems Centre** in the 1970s. Earlier India has imported Vikas engines from French components. It is used in PSLV and GSLV series of expendable launch vehicles for space launch use.

Vikas engine is used to power the second stage of PSLV, boosters and second stage of GSLV Mark I and II and also the core stage of **GSLV Mark III**. The propellant loading for Vikas engine in PSLV, GSLV Mark I and II is 40 tons, while in GSLV Mark III is 55 tons.

(Refer Infographic – PSLV, GSLV & GSLV-MKIII)

## 7.7 MISCELLANEOUS: LAUNCH VEHICLE AND MISSILES

### 7.7.1 Small Satellite Launcher

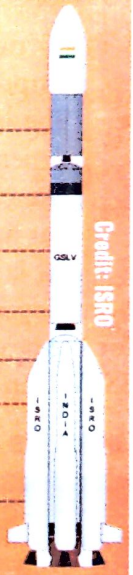
Small Satellite Launch Vehicle (SSLV) is ISRO's indigenous new launch rocket, is likely to have its much-delayed, maiden development flight this 3rd/4th quarter of 2022.

## 3rd Gen LV- PSLV (Polar Satellite Launch Vehicle)

Credit: ISRO

1. Polar Satellite Launch Vehicle (PSLV) is the third generation launch vehicle of India. It is the first Indian launch vehicle to be equipped with liquid stages. After its first successful launch in October 1994, PSLV emerged as a reliable and versatile workhorse launch vehicle of India.
2. PSLV has also been used to launch various satellites into Geosynchronous and Geostationary orbits, like satellites from the IRNSS Constellation.
3. The vehicle successfully launched two spacecraft "Chandrayaan-1 in 2008 and Mars Orbiter Spacecraft in 2013" that later travelled to Moon and Mars respectively. Chandrayaan-1 and MOM (Mars Orbiter Mission) were feathers in the hat of PSLV.
4. PSLV earned its title 'the Workhorse of ISRO' through consistently delivering various satellites to Low Earth Orbits. It can take up to 1,750 kg of payload to Sun-Synchronous Polar Orbits of 600 km altitude.
5. First Flight: September 20, 1993 (Unsuccessful Mission)
6. Variants: 4 (PSLV,CA,DL,QL,XL)
7. **Stages of PSLV Launch**
   - 1st Stage- PSLV uses the S139 solid rocket motor that is augmented by 6 solid strap-on boosters.
   - 2nd Stage- PSLV uses an Earth storable liquid rocket engine for its second stage, know as the Vikas engine, developed by Liquid Propulsion Systems Centre.
   - 3rd Stage- The third stage of PSLV is a solid rocket motor that provides the upper stages high thrust after the atmospheric phase of the launch.
   - 4th Stage- The PS4 is the uppermost stage of PSLV, comprising of two Earth storable liquid engines.

## 4th Gen LV- GSLV (Geosynchronous Satellite Launch Vehicle)



Credit: ISRO

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Geosynchronous Satellite Launch Vehicle Mark II (GSLV MK II) is the launch vehicle developed by India, to launch communication satellites in geo transfer orbit using cryogenic third stage.

Initially Russian GK supplied cryogenic stages were used. Later cryogenic stage was indigenously developed and inducted in Jan 2014 from GSLV D5 onwards.

This operational fourth generation launch vehicle is a three stage vehicle with four liquid strap-ons. The flight proven indigenously developed Cryogenic Upper Stage (CUS), forms the third stage of GSLV MK II.

From January 2014, the vehicle has achieved six consecutive successes.

First Flight: April 18, 2001 | First Flight (With Indigenous Cryo Stage) : January 5, 2014

The name Chandrayaan means "mooncraft" in Sanskrit and Hindi. The mission was launched on a Geosynchronous Satellite Launch Vehicle Mark III (GSLV MK-III) M1.

**Stages of GSLV Launch**

1st Stage (GS1)- The first stage of GSLV was also derived from the PSLV's PS1. The 138 tonne solid rocket motor is augmented by 4 liquid strap-ons.
2nd Stage (GS2)- One Vikas engine is used in the second stage of GSLV. The stage was derived from the PS2 of PSLV where the Vikas engine has proved its reliability.
3rd Stage (CUS)- Developed under the Cryogenic Upper Stage Project (CUSP), the CE-7.5 is India's first cryogenic engine, developed by the Liquid Propulsion Systems Centre. CE-7.5 has a staged combustion operating cycle.

## 5th Gen LV-GSLV MK-III (Geosynchronous Satellite Launch Vehicle Mark III)

Credit: ISRO

1. LVM III is configured as a three stage vehicle with two solid strap-on motors (S200), one liquid core stage (L110) and a high thrust cryogenic upper stage (C25).
2. The S200 solid motor is among the largest solid boosters in the world with 204 tonnes of solid propellant. The liquid L110 stage uses a twin liquid engine configuration with 115 tonnes of liquid propellant, while the C25 Cryogenic upper stage is configured with the fully indigenous high thrust cryogenic engine (CE20) with a propellant loading of 28 tons.
3. LVM III is the new heavy lift launch vehicle of ISRO for achieving a 4000 kg spacecraft launching capability to GTO (Geosynchronous Transfer Orbit) in a cost effective manner.
4. From January 2014, the vehicle has achieved six consecutive successes.
5. First Flight: Dec 18, 2014
6. **Stages of GSLV MK-III Launch**
   - Core Stage : L110 Liquid Stage- The L110 liquid stage is powered by two Vikas engines designed and developed at the Liquid Propulsion Systems Centre.
   - Solid Rocket Boosters : S200: - LVM III uses two S200 solid rocket boosters to provide the huge amount of thrust required for lift off. The S200 was developed at Vikram Sarabhai Space Centre.
   - Cryogenic Upper Stage : C25: - The C25 is powered by CE-20, India's largest cryogenic engine, designed and developed by the Liquid Propulsion Systems Centre.

One of the aims of the newly created ISRO's commercial arm, NewSpace India Limited (NSIL), is to use research and development carried out by ISRO over the years for commercial purposes through Indian industry partners.

"Manufacturing and production of Small Satellite Launch Vehicle (SSLV) and Polar Satellite Launch Vehicle (PSLV) through technology transfer," is one of the mandates of the new firm.

There are more than 500 industries contributing to ISRO programs at present, and more than half of the project budget outlay for space programs flows to these industries.

- The SSLV is intended to cater to a market for the launch of small satellites into low earth orbits, which has emerged in recent years on account of the need for developing countries, private corporations, and universities for small satellites.
- The launch of small satellites has until now been dependent on 'piggy-back' rides with big satellite launches on ISRO's workhorse – the PSLV, which has had over 50 successful, launches so far.

The launch of small satellites as a consequence has been dependent on the finalising of launch contracts for the larger satellites by ISRO. **Table 7.9** lists various SSLV launched till date.

**TABLE 7.9 List of SSLV Launches**

| Title | Launch Date | Launcher Type | Payload |
|---|---|---|---|
| SSLV-D2/EOS-07 MISSION | Feb 10, 2023 | SSLV | EOS-07 |
| SSLV-D1/EOS-02 Mission | Aug 07, 2022 | SSLV | EOS-02 |

*Source:* https://www.isro.gov.in (last accessed in June 2023)

### *Features*

- SSLV is a 4-stage Launch Vehicle with the first 3 stages of the vehicle using HTPB-based solid propellant, with a fourth terminal stage being a Velocity-Trimming Module (VTM).
- The SSLV can carry satellites weighing up to 500 kg to a low earth orbit.
- The SSLV is the smallest vehicle at 110-ton mass at ISRO.
- It will be an on-demand vehicle.
- SLV is perfectly suited for launching multiple microsatellites at a time and supports multiple orbital drop-offs.

### *Significance*

- **Less time:** It will take only 72 hours to integrate, unlike the 70 days taken now for a launch vehicle.
- **Less manpower:** Only six people will be required to do the job, instead of 60 people.
- **Saving cost:** The entire job will be done in a very short time and the cost will be only around ₹30 crore.
- **Build synergy:** The development and manufacture of the SSLV are expected to create greater synergy between the space sector and private Indian industries – a key aim of the space ministry.

## 7.7.2 ISRO's Own Next-Gen Launch Vehicle (NGLV)

ISRO is developing a Next-Gen Launch Vehicle (NGLV) intended to replace PSLV.

### *Features of NGLV*

- 3-Stage Launch Vehicle, reusable heavy lift vehicle
- Use semi-cryogenic propulsion for booster stages
- 10-tonne payload capability to Geostationary Transfer Orbit
- Cost efficient
- Simple, robust design allowing bulk manufacturing

### *Potential Uses*

Launching communication satellites, Deep space missions, Future human space flight and cargo missions, ISRO is intending to develop a business model for NGLV to launch commercial as well as national missions.

## 7.7.3 India's Anti-Satellite (A-SAT) Missile/ Mission Shakti

A joint programme of DRDO and ISRO, **Mission Shakti**, as part of the mission, **an anti-satellite (A-SAT) weapon** was launched and targeted on an Indian satellite which had been decommissioned. It was carried out from DRDO's testing range in Balasore, Odisha.

After US, Russia and China, India became the 4$^{th}$ country to acquire such a specialised and modern capability, and the entire effort is indigenous. With this satellite we now have the capability to hit a live target in space.

### 7.7.4 Reusable Launch Vehicle – Technology Demonstrator (RLV-TD)

Developing the Reusable Launch Vehicle – Technology Demonstrator (RLV-TD) was a technologically challenging endeavour of ISRO, which India has achieved now. Access of reusable launch vehicle technology will minimise the cost for various space missions. In May 2016, it was successfully tested for its autonomous navigation, reusable thermal protection system, guidance and control, and re-entry mission management. The configuration of RLV-TD is similar to that of an aircraft and combines the complexity of both launch vehicles and aircraft.

(Refer **Infographic – SSLV, RLV-TD**)

## 7.8 JET ENGINE TECHNOLOGY

### 7.8.1 Normal Aircraft versus Jet Plane

Normal aircrafts have light-weight piston engines or gas turbines but advanced jet planes have turbojet, ramjet and scramjet engines.

Normal aircrafts move through troposphere but jet planes move very easily and smoothly in stratospheric zone. The stratosphere lies above the troposphere (where the temperature increases with increase in altitude). The stratosphere extends to an altitude of about 50 kilometres. Compared to troposphere, the airflow in the stratosphere is much less turbulent. Since the air does not flow up and down, and flows parallel to the Earth in very fast moving air streams, this is the layer where most of the jet planes fly. There is significant difference in the temperature gradients, and hence the tropospheric air does not mix into the stratospheric air. The stratosphere is more layered or 'stratified' because of lack of mixing and less turbulence.

### 7.8.2 Types of Jet Plane

Jet engine technology works on the basis of Newton's third law of action and reaction. Three principles are involved in any type of jet engine orderly compression, combustion and expansion. There are three types of jet engine technology evolved, namely turbojet, ramjet and scramjet.

A reaction engine which releases air with high velocity and results in the production of thrust through jet impulsion is known as jet engine. Jet engine is commonly referred as internal combustion air breathing engine. Such engines classically have a rotating air compressor, which is turbine powered, with the residual power providing thrust through a propelling nozzle and the process is termed as the Brayton thermodynamic cycle. These engines are used by jet aircrafts for long-distance travel.

The earlier jet aircrafts used turbojet engines, which were comparatively incompetent for subsonic flights. The current subsonic jet aircrafts generally make use of much complex high-bypass turbofan engines. These engines are offering superior speed and better efficiency of fuel over large distances in comparison to piston and propeller-featured aero engines.

The jet engines lacking inlet systems can only admit air at about half the sound speed. The only exception to this is scramjets. The inlet system slows the air movement and carries out the compression for transonic and supersonic aircrafts.

The flammability sets the upper altitude limit for engines, such as during very high altitudes, the air is too thin and it becomes too hot after compression. The **turbojet engines** can attain nearly 40 kilometre altitudes, whereas around 55 kilometres can be achieved for **ramjet engine**. Theoretically, **scramjets** can reach up to 75 kilometres. On the other hand, the rocket engines have no upper limit.

Note: Rocket engines always carry own oxidiser because it goes in outer atmosphere where air is absent. Jet planes can always be up to that height where oxygen is present because they take atmospheric oxygen. Stratosphere is that part of atmosphere where oxygen is always present.

### 7.8.3 Ramjet and Scramjet

(Refer **Infographic – Turbojet, Ramjet & Scramjet**)

Note: ISRO's first experimental test of scramjets was successful on 28 August 2016. It tested its engine that later touched down at Bay of Bengal after a flight time of 300 seconds. During its 300-second course, the flight was successfully tracked and managed from ground stations. Hydrogen was used as fuel and the Ramjet breathed the atmospheric air of oxygen as oxidiser, thus attaining Mach 6. ISRO's Advanced Technology Vehicle (ATV) is an advanced sounding rocket, used for its lift off that together weighed 3277 kilograms at lift off. India is the fourth country to demonstrate the flight testing of a scramjet engine after US, Russia and European Union.

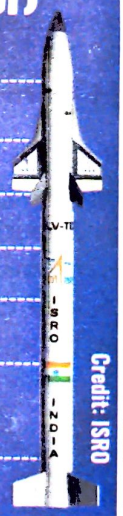
# SSLV (Small Satellite Launch Vehicle)

Credit: ISRO

1. Small Satellite Launch Vehicle (SSLV) is a three stage Launch Vehicle configured with three Solid Propulsion Stages and liquid propulsion based Velocity Trimming Module (VTM) as a terminal stage.
2. SSLV is 2 m in diameter and 34 m in length with lift off weight of ~120 tonnes.
3. It is a three-stage all-solid vehicle with the capacity to launch a 500 kg satellite into a 500 km Low earth orbit and 300kg into a Sun-synchronous orbit.
4. The key features of SSLV are low cost, with low turn-around time, flexibility in accommodating multiple satellites, launch on demand feasibility, minimal launch infrastructure requirements, etc.
5. Vehicle Configuration: Three Solid propulsion stages Liquid module as terminal stage
6. **Stages of SSLV Launch**
   - Stage 1 (SS1)- Fuel: HTPB based Solid Propellant
   - Stage 2 (SS2)- Fuel: HTPB based Solid Propellant
   - Stage 3 (SS3)- Fuel: HTPB based Solid Propellant

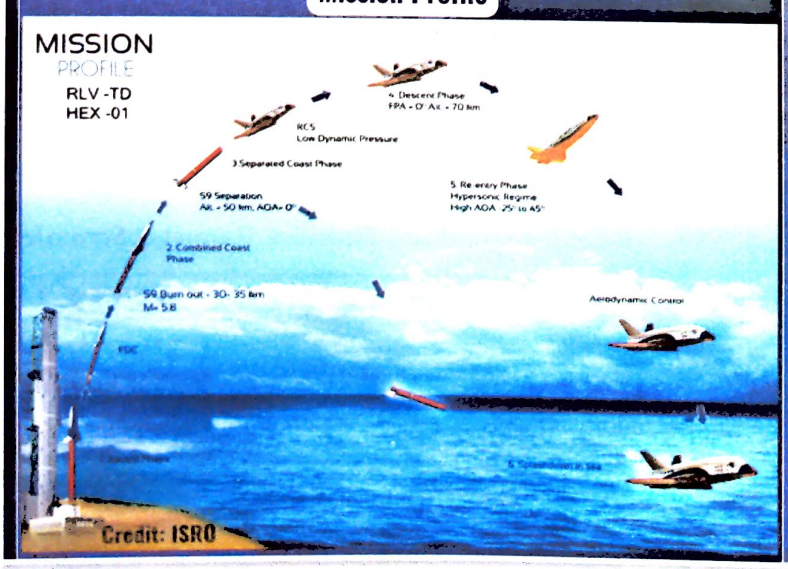
# RLV-TD (Reusable Launch Vehicle - Technology Demonstrator)

1. Reusable Launch Vehicle – Technology Demonstrator (RLV-TD) is one of the most technologically challenging endeavors of ISRO towards developing essential technologies for a fully reusable launch vehicle to enable low cost access to space.
2. The configuration of RLV-TD is similar to that of an aircraft and combines the complexity of both launch vehicles and aircraft.
3. The winged RLV-TD has been configured to act as a flying test bed to evaluate various technologies, namely, hypersonic flight, autonomous landing and powered cruise flight.
4. In future, this vehicle will be scaled up to become the first stage of India's reusable two stage orbital launch vehicle.
5. RLV-TD consists of a fuselage (body), a nose cap, double delta wings and twin vertical tails. It also features symmetrically placed active control surfaces called Elevons and Rudder.
6. RLV-TD was successfully flight tested on May 23, 2016 from SDSC SHAR Sriharikota validating the critical technologies such as autonomous navigation, guidance & control, reusable thermal protection system and re-entry mission management.
7. **Objectives**
   - Hypersonic aerothermodynamic characterization of wing body
   - Evaluation of autonomous Navigation, Guidance and Control (NGC) schemes
   - Integrated flight management
   - Thermal Protection System Evaluation



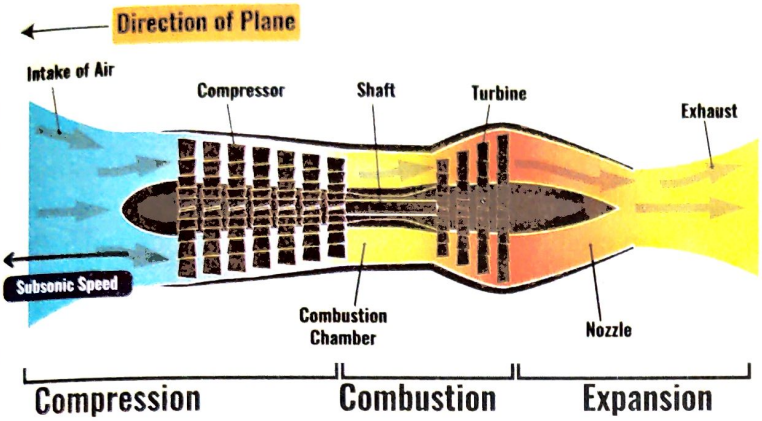

Credit: ISRO

## Mission Profile



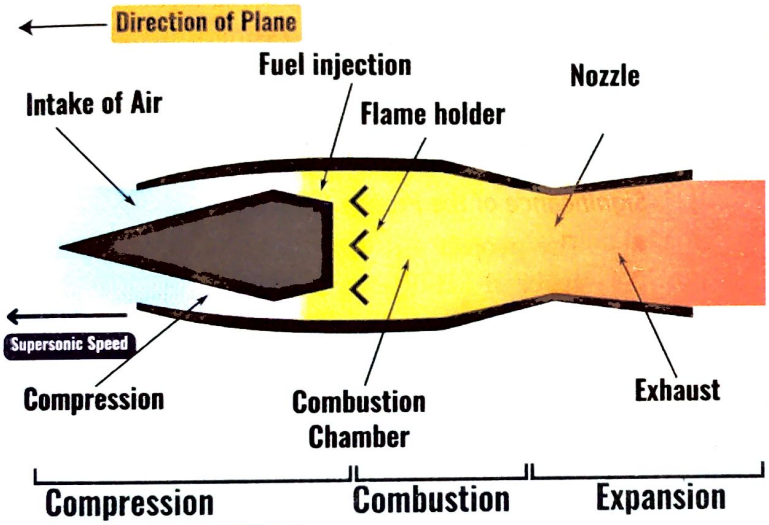

## Data Communication

# TURBOJET vs RAMJET vs SCRAMJET



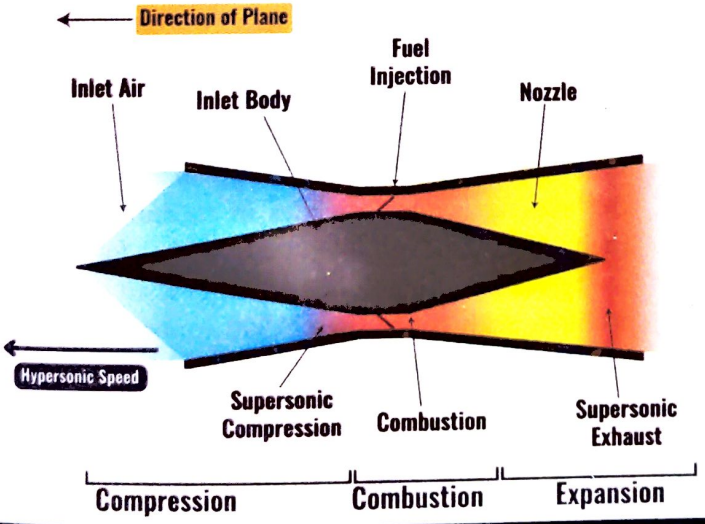

## TURBOJET

- It is **oldest and most widely used type of jet engine.**
- Turbojets have a straightforward design, comprising a **compressor, combustion chamber, and exhaust nozzle.**
- Turbojet engines **function at subsonic speeds** and utilize a combination of fans and compressors to compress air prior to entering the combustion chamber.
- The compressed air and fuel mixture in a turbojet engine undergoes combustion, generating high-pressure exhaust gases that provide thrust.
- Turbojet engines are **highly efficient when operating at subsonic speeds, typically below Mach 2.5.** This efficiency makes them well-suited for commercial aviation purposes.




## RAMJET

- Ramjet engines are engines **designed for supersonic speeds** that operate without the presence of a compressor or turbine.
- Ramjets have a **complex design** that necessitates a significant amount of kinetic energy to initiate and maintain their operation.
- The compressed air and fuel mixture in a ramjet engine undergoes combustion, resulting in the production of thrust.
- Ramjets are most efficient when **operating at supersonic speeds, typically above Mach 3.**
- This quality **makes them highly suitable for use in high-speed military aircraft and missiles.**
- Ramjets require a significant amount of kinetic energy to start and are not suitable for low-speed flight.




## SCRAMJET

- Scramjet engines are a specific type of engine known as **supersonic combustion ramjet engines.** They are designed to operate at hypersonic speeds, typically exceeding Mach 5.
- Like ramjets, scramjet engines do not incorporate a compressor or turbine. Instead, **they depend on the velocity of the aircraft to compress air** before it enters the combustion chamber.
- Scramjet engines are designed with a complex configuration that enables them to achieve efficient operation at hypersonic speeds.
- Scramjet engines exhibit **higher efficiency compared to rockets,** making them well-suited for applications in space exploration and high-speed aircraft.

**NOTE:**

- **Scramjets have no moving parts, and ramjets have fewer moving parts than turbojets, which makes them more reliable and easier to maintain.**
- **In terms of specific applications, turbojets are most commonly used in commercial and military aircrafts, while scramjets and ramjets are primarily used in missiles and hypersonic vehicles.**

## 7.9 INDIAN ASTRONOMICAL OBSERVATORY (IAO)

The Indian Astronomical Observatory is currently the world's third highest optical telescope at one of the world's highest sites (at an elevation of 4,500 metres) located near Leh in Ladakh, India. It works through infrared, gamma-ray and optical telescopes. The Indian Institute of Astrophysics, Bengaluru operates this observatory.

It has two dynamic telescopes – one is Himalayan Chandra Telescope (HCT), having a 2.01 metre diameter and the other is a high altitude Gamma Ray Telescope.

**CENTRE FOR RESEARCH AND EDUCATION IN SCIENCE AND TECHNOLOGY**

The Centre for Research and Education in Science and Technology (CREST) is situated 35 km to the northeast of Bangalore near Hoskote town. The Centre houses the control room for the remote operations of the 2 m Himalayan Chandra Telescope (HCT) at the Indian Astronomical Observatory, Hanle, and the HCT data archive. The operations are controlled using a remote satellite link.

### *Himalayan Chandra Telescope*

The Himalayan Chandra Telescope is an optical-infrared telescope having 2.01 metres diameter, which is approximately 6.5 feet. This is developed by Electo-Optical Technologies System based at Arizona, USA. The telescope is operated remotely from the Centre for Research and Education in Science and Technology at Bengaluru with the help of a dedicated satellite link. The telescope is remotely operated via an INSAT-3B satellite link, which allows operation even in sub-zero temperatures in winter.

### *High Altitude Gamma Ray Telescope*

The High Altitude Gamma Ray Telescope (HAGAR) is an atmospheric Cerenkov experiment with seven telescopes setup in 2008. Each telescope has seven mirrors with a total area of 4.4 square metres. The telescopes are deployed on the periphery of a circle of radius 50 metres with one telescope at the centre.

### *GROWTH-India Telescope*

The GROWTH-India telescope is a 0.7 metre wide-field optical telescope that had first light in 2018. It is the **country's first fully robotic research telescope.** It was set up as a part of the international GROWTH programme, and has been widely used for time domain astronomy. **The telescope is operated jointly by IIT Bombay and the Indian Institute of Astrophysics.**

## 7.10 PROJECT NETRA (NETWORK FOR SPACE OBJECT TRACKING AND ANALYSIS)

ISRO has inked a pact with Indian Institute of Astrophysics (IIA) to pave the way for collaboration in establishing optical telescope facilities under ***Project 'NETRA'*** for tracking space objects.

ISRO has initiated ***'Project NETRA'*** as an early warning system in space to detect debris and other hazards to Indian satellites. Under the project, ISRO plans to put up many observational facilities: connected radars, telescopes; data processing units and a control centre. They can, among others, spot, track and catalogue objects as small as 10 cm, up to a range of 3,400 km and equal to a space orbit of around 2,000 km.

### *Significance of the Project*

- The project will give India its own capability in space situational awareness (SSA) like the other space powers, which is used to 'predict' threats from debris to Indian satellites.
- NETRA's eventual goal is to capture the GEO, or geostationary orbit, scene at 36,000 km where communication satellites operate.
- The effort would make India a part of international efforts towards tracking, warning about and mitigating space debris.

Currently there are many functional Indian communication satellites in the geostationary orbit of 36,000 km; remote sensing satellites in LEO of up to 2,000 km; and navigation satellites in medium earth orbits. Their protection is of utmost importance for India.

Space junk (Kessler Syndrome) is an ever-growing problem with more than 7,500 tonnes of redundant hardware now thought to be circling the Earth. The old rocket bodies and defunct spacecraft through to screws and even flecks of paint are such material that pose a collision hazard to operational missions. The rise in space debris increases the potential danger to all space vehicles, and especially to the International Space Station (ISS), space shuttles, satellites and other spacecraft.

## 8.1 UNITED NATIONS OFFICE FOR OUTER SPACE AFFAIRS (UNOOSA): ROLES AND RESPONSIBILITIES

- The UNOOSA is the United Nations office responsible for promotion of international cooperation in the peaceful uses of outer space.
- UNOOSA works as the secretariat for the General Assembly's only committee the United Nations "Committee on the Peaceful Uses of Outer Space" (COPUOS), dealing exclusively with international cooperation in the peaceful uses of outer space.
  UNOOSA conducts international workshops, training courses and pilot projects on topics including satellite navigation, satellite meteorology, remote sensing, tele-education and basic space sciences for the benefit of developing nations via the United Nations Programme on Space Applications.
  During disasters, it manages the United Nations Platform for **Space-based Information for Disaster Management and Emergency Response** (UN-SPIDER) and maintains a 24-hour hotline as the United Nations focal point for satellite imagery requests during disasters.
- The current secretariat of the International Committee on Global Navigation Satellite Systems (ICG) is UNOOSA (**United Nations Office for Outer Space Affairs**).
- It also prepares and distributes reports, studies and publications on various fields of space science and technology applications and those related to international space law. Documents and reports are available through its website in all official languages of the United Nations. UNOOSA is located at the United Nations Office at Vienna, Austria.

## 8.2 SPACE LAW

- The body of law governing space-related activities is described as Space Law.
- It comprises of a variety of international agreements, treaties, conventions, and United Nations General Assembly resolutions, along with rules and regulations of international organisations.
- "Space Law" is associated with the rules, principles and standards of international law appearing in the five international treaties and five sets of principles governing outer space, developed under the auspices of the United Nations.
- Space Law addresses a variety of matters, for instance, the preservation of the space and Earth environment, liability for damages caused by space objects, the rescue of astronauts. Other important applications include the settlement of disputes, the sharing of information about potential dangers in outer space, the use of space-related technologies, and international cooperation. The fundamental principles guiding the conduct of space activities include the notion of space as the province of all humankind, the freedom of exploration and use of outer space by all states without discrimination, and the principle of non-appropriation of outer space.
- Upon request, the Office provides information and advice to governments, non-governmental organisations and the general public, on Space Law as an objective to promote understanding, acceptance and implementation of the international space law agreements concluded under United Nations auspices.

### *Space Law in India*

- An international dispute arose when debris of an Indian satellite from orbit fell back to Earth and landed on a fishing village in Japan. In another such instance, an Indian Space Research Organisation rocket launch failed and it blew up on the launching pad, which destroyed a dozen countries' satellites, which were on the launching stage.
- The Government of India (GoI) unleashed reforms in space domain in 2020, opening the doors for enhanced participation of NGEs in carrying out end-to-end activities in the space domain and with an aim to provide them a level playing field. Subsequent to these reforms, the Government seeks to provide regulatory certainty to space activities by various stakeholders, in order to create a thriving space ecosystem.
- The new Indian Space Policy, 2023 made public on April 20, 2023 has been formulated as an

overarching, composite and dynamic framework to implement the reform vision approved by the Cabinet.

- Vision: To augment space capabilities; enable, encourage and develop a flourishing commercial presence in space; use space as a driver of technology development and derived benefits in allied areas; pursue international relations, and create an ecosystem for effective implementation of space applications among all stakeholders; for the nation's socio-economic development and security, protection of environment and lives, pursuing peaceful exploration of outer space, stimulation of public awareness and scientific quest.
- Authority: IN-SPACe shall function as an autonomous Government organisation, mandated to promote, hand-hold, guide and authorise space activities in the country. For this purpose, IN-SPACe shall periodically issue guidelines and procedures, that would among other things promote ease of doing business.
- ISRO, as the National Space Agency, will focus primarily on research and development of new space technologies and applications, and for expanding the human understanding of outer space.
- NewSpace India Limited
- Department of Space
- Jurisdiction: This policy is applicable to any space activity to or from the Indian Territory or within the jurisdiction of India including the area to the limit of its exclusive economic zone. Notwithstanding anything contained in this policy, the GoI reserves its right to provide exemptions to the provisions contained herein on a case-to-case basis.

## 8.3 SUCCESSFUL SPACE MISSION OF INDIA

### 8.3.1 Chandrayaan I

- ISRO's first mission to moon was an unmanned lunar spacecraft launched successfully on **22 October 2008** from SDSC, Sriharikota. On 12 November 2008, with 2 years of life span, the probe was successfully inserted into lunar orbit. Through this mission, several questions related to the moon's origin, evolution and chemical as well as physical structure got answered. More than ₹380 crores were spent on this mission, while a thousand scientists worked on it.
- Chandrayaan I is a cuboid shaped satellite **weighing 1,380 kilograms** at lift off. There were **11 payloads** on-board the satellite. It was a 3-axis stabilised spacecraft deploying two star sensors. The spacecraft was powered by solar arrays and by lithium ion batteries during eclipse. Out of the **11 payloads** on Chandrayaan I, most of them were foreign countries' payloads.
- The major payloads by India were a Terrain Mapping Camera (with resolution of 5 metres), Hyper Spectral Imager (HySI) for mineralogical mapping, Lunar Laser Ranging Instrument, and Moon Impact Probe for the demonstration of technologies needed for crash landing on the surface of the Moon.
- Some major payloads by foreign countries included Moon Mineralogy Mapper (NASA) to provide a map of the entire lunar surface, X-ray Fluorescence Spectrometer, High Energy X-ray Spectrometer, Miniature Synthetic Aperture Radar, Radiation Dose Monitor Experiment (Bulgarian Academy of Sciences), Infrared Spectrometer (European Space Agency).
- The probe (as mentioned above), was said to have a **life span of 2 years**, but ISRO lost contact with it in August 2009 due to the failure of the star sensors, and unusually high levels of radiation fried the communications array, as per some scientists.
- According to ISRO officials, the mission had achieved 95% of its objectives before losing all contacts. The mission was officially decommissioned on 30 August 2009. The mission helped **map 50% of the lunar surface**, and **more than 90% of the mineralogy**. It was the first mission that had a satellite as low as 100 kilometres from the moon's surface. Chandrayaan I took around 70,000 photographs of the lunar surface with an unbeatable resolution of 5 metres, which helped to confirm the presence of **iron and iron-bearing minerals (pyroxene),** and **evidences of water** on the moon.
- **US, former Soviet Union, Japan** (albeit via a malfunction that sent its orbiter crashing onto the

lunar surface) and the **European Space Agency** (17 nations) were other countries which have reached the Moon and India becomes the fifth member of this club.

- This mission bagged many other notable awards and recognitions, along with the 2009 Annual **AIAA Space Awards [American Institute of Aeronautics and Astronautics (AIAA)]** and one for accommodating most international payloads ever.

### 8.3.2 Mars Orbiter Mission (MOM/Mangalyaan)

- Mars, among all the other planets, has been the centre of prime attraction since years of research. Its atmospheric values and somewhat Earth-like gravity may point towards the fact that it can be inhabited.
- India became the **first country to reach the Mars orbit successfully in the first attempt** via Mars Orbiter Mission of ISRO (which stands out to be first interplanetary mission making history).
- On 5 November 2013, it was launched from Satish Dhawan Space Centre by PSLV-C25 with an approximate launch mass of 1,350 kilograms.
- It was launched on Mars with an objective to explore the surface features, morphology, mineralogy and Martian atmosphere.
- It had **five scientific payloads**. The following components of the Mangalyaan have specific functions and roles: Mars Colour Camera (MCC) provides information about surface features of Mars while for picking up methane traces in the atmosphere, it is equipped with Methane Sensor for Mars. Thermal Infrared Imaging Spectrometer enables measurement of the surface temperature. Mars Exospheric Neutral Composition Analyser performs analysis of the neutral composition of particles in the range of 1–300 amu (atomic mass unit) with unit mass resolution. Lyman-Alpha Photometer for measurement of relative abundance of Deuterium and Hydrogen from Lyman-alpha emissions in the upper atmosphere.
- Its team won the US-based National Space Society's **"Space Pioneer Award"** for science and engineering category for the year 2015. ISRO also bagged the 2014, **"Indira Gandhi Prize for Peace, Disarmament and Development"** for its significant contribution towards strengthening international cooperation in peaceful use of outer space. **Mangalyaan's success makes India only the fourth entity and the first Asian nation to put a spacecraft in Mars' orbit, after the United States, the Soviet Union, and the European Space Agency. It also accords to be the first country anywhere to do so on its first attempt.**

### 8.3.3 Astrosat

- India's first dedicated **multi-wavelength space observatory** is ASTROSAT.
- It is ISRO's first satellite dedicated towards the study of celestial sources, or as commonly said – stars, in X-ray, optical, and UV spectral band with a **lift-off mass of 1,513 kilograms**.
- Its unique features include simultaneous multi-wavelength observations of various astronomical objects with a single satellite. It is said to have a minimum useful life of five years.
- India joined the elite list of countries having its own space observatory after the US, Japan, Russia and Europe, with the successful launch of ASTROSAT.
- In **September 2015**, it was launched by a **PSLV-C30**, into a 650-kilometre orbit.
- It aims at apprehending the high-energy processes in binary star systems containing neutron stars and black holes, and estimate the star's magnetic fields and study star birth regions and processes in star systems beyond our galaxy. Additionally, it helps to detect new bright sources of X-ray (expecting new stars) and, a deep field survey of the Universe in the Ultraviolet region.
- **Five payloads** of ASTROSAT are chosen to facilitate a deeper insight into the various astrophysical processes occurring in the various types of astronomical objects constituting our universe. These payloads are – Ultraviolet Imaging Telescope (UVIT), Large Area X-ray Proportional Counter (LAXPC), Soft X-ray Telescope (SXT), Cadmium Zinc Telluride Imager (CZTI), and Scanning Sky Monitor (SSM).

**KEY POINTS**

- AstroSat is **India's first multi-wavelength space telescope, which has five telescopes** seeing through different wavelengths simultaneously – visible, near UV, far UV, soft X-ray and hard X-ray.
- Onboard the AstroSat is a 38-cm wide **Ultra Violet Imaging Telescope (UVIT)**, which is capable of imaging in far and near-ultraviolet bands over a wide field of view.
- It is a **multi-institute collaborative project**, involving IUCAA, ISRO, Tata Institute of Fundamental Research (Mumbai), Indian Institute of Astrophysics (Bengaluru), and Physical Research Laboratory (Ahmedabad), among others.

### 8.3.4 Chandrayaan-2

- In September 2008, the mission of Chandrayaan-2 was approved by the government for a cost of ₹425 crore. It is India's **second unmanned mission to the moon**. It aims **to explore the Moon's South Polar Region**.
- **The Chandrayaan-2 is an Indian Space Research Organization (ISRO) lunar mission *comprising an orbiter, lander (Vikram) and a rover (Pragyan), with a lift-off mass of 3877 kg. This was the first space mission to conduct a soft landing on the Moon's South Polar Region which has a lunar surface area much larger than that of the North Pole and remains in shadow.***
- The **mission payloads include** – Terrain Mapping Camera which will generate a Digital Elevation Model (DEM) of the entire moon, Chandrayaan-2 Large Area Soft X-ray Spectrometer which will test the elemental composition of the Moon's surface Solar X-Ray Monitor which will provide solar X-ray spectrum inputs for CLASS.

***Objectives of the Mission***

- The primary objective of Chandrayaan-2 is **to demonstrate the ability to soft-land on the lunar surface and operate a robotic rover on the surface. Scientific goals include studies of lunar topography, mineralogy, elemental abundance, the lunar exosphere, and signatures of hydroxyl and water ice.**
- **India's rocket** carrying **an orbiter, lander and a rover** in a stepped up moon mission launched into space successfully from the Sriharikota launch pad on ***22 July 2019***. The **Chandrayaan-2** is on course to place the country in a niche league of nations populated by the ***US, Russia and China that have successfully conducted a moon-landing.*** **India will be 4th country to land a spacecraft on moon.**
- **The lander will touch in the region of the south pole of the moon, an unexplored territory.** The target is to find more **evidence of water, clues about the moon's evolution** and **work the natural satellite** as a test bed for more space missions concerning the solar system. **The launch vehicle, the GSLV Mk-3, is the country's most powerful rocket to date. This will be the first operational flight of GSLV-Mk-3.**
- **The *1400 kg Lander, Vikram*, will be alive for 14 earth days, or one day in the moon. It can communicate with the orbiter 100 km from the surface of the moon, and ISRO's earth station near Bengaluru.** But Vikram **lander** lost contact with ground control around 2.1 km from the lunar surface, during its soft landing.
- Chandrayaan-2 is loaded with **13 payloads (Orbiter – 8 Payloads, Lander – 3 Payloads & Rover – 2 Payloads)** that will carry out detailed study of topography, seismography, mineral identification and distribution, surface chemical composition, thermo-physical characteristics of top soil and composition of the tenuous lunar atmosphere for a new understanding of the origin and evolution of Moon.

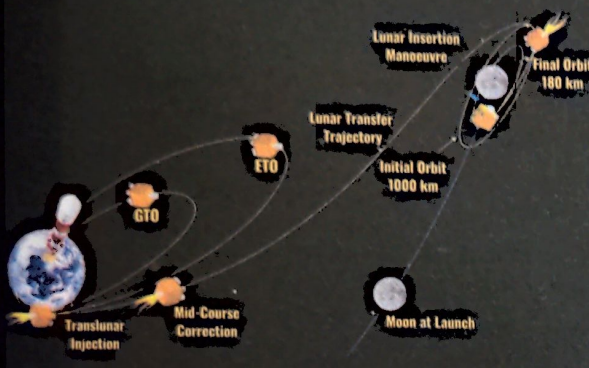
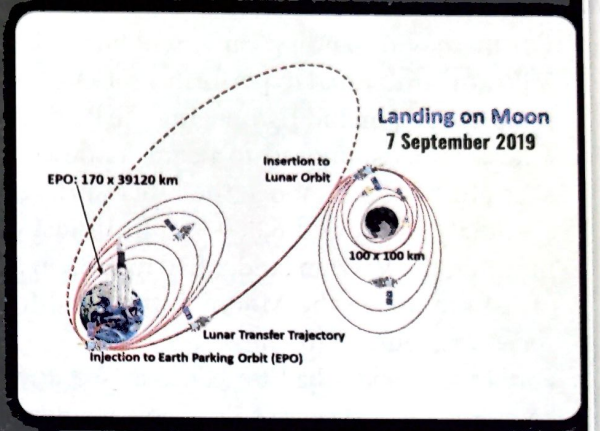
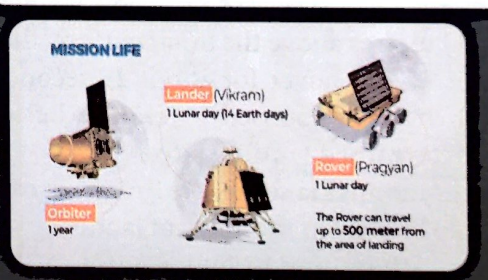
(Refer **Infographic – Chandrayaan-1 Chandrayaan-2**)

**SOFT LANDING**

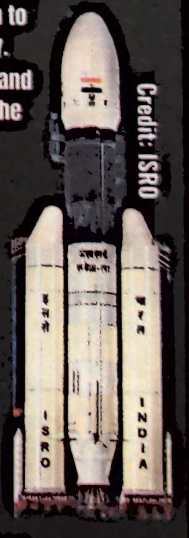
- A soft-landing protects the object from impact while a hard landing doesn't.
- Soft-landing ensures that the object is able to carry out further experimentation on the target planet or satellite, mostly with the help of a rover vehicle.
- Soft-landing on any planetary surface is complicated. **Vikram was to use five thrusters** – four at the corners and one at the centre to make its final descent.
- Maintaining the required velocity with such thrusters is difficult as a fine balance among them needs to be maintained.
- Then there is the issue of moon dust which could wreck the engines of the thrusters.

# CHANDRAYAAN

## 1 vs 2

| Chandrayaan-1 | | Chandrayaan-2 |
|---|---|---|
|  | Trajectory |  |
| | Components |  |
| • India's 1st Lunar Mission<br>• India's 1st Deep Space Mission | Misson | • Follow up mission of Chandrayaan-1<br>• ISRO's 1st interplanetary mission to land Rover on any celestial body.<br>• Demonstrate the ability to soft-land and operate a robotic rover on the lunar surface. |
| • Orbiting Around Moon | Goals | |
| • Rs. 380 Cr | Cost | • Rs. 960 Cr |
| • PSLV-C-11 | Launch Vehicle | • GSLV MK-III (M1) |
| • 22 October 2008 | Launch Date | • 22 July 2019 |
| • 312 Days | Operational Days | • Orbiter still functional (Extended for 7 years) |
| • Built in India, UK, USA, Germany, Sweden and Bulgaria | 11 Payloads 14 | • 14 (13 Indian and 1 from NASA) |
| • To conduct scientific experiments using instruments on spacecraft. To increase scientific knowledge. | Major | • To soft land on lunar surface<br>• Test new technologies and conduct experiments on the moon |

Credit: ISRO



Credit: ISRO

**Only USA, Russia and China have been able to soft land on lunar surface**

### WHY EXPLORE THE LUNAR SOUTH POLE?

The South Pole is especially interesting because of the lunar surface area here that remains in shadow are much larger than that at the North Pole. There's a possibility of presence of water in permanently shadowed areas around it. Also, South Pole region has craters that are cold traps and contain a fossil record of the early Solar System.

***What was Supposed to Happen?***

- On the day of landing on 7 September 2019, **the Vikram lander** had to perform a series of complex manoeuvres, including imaging the landing site.
- **Vikram** was supposed to begin its descent from a height of 35 km above the lunar surface and at a velocity of around 6,000 kmph. In just over 10 minutes, the Vikram lander had to drop to a height of 7.4 km above the Moon altitude and lower its speed to around 526 kmph.
- Further, the lander had to reduce its speed to 0331.2 kmph and reach a height of 5 km above the lunar surface.
- At 100 metres above the lunar surface, the Vikram lander had to hover for about 25 seconds during which it was supposed to **choose between two pre-determined landing sites**.
- Four hours after landing, the **Pragyan rover** would be unloaded from the Vikram lander.

**ISRO** is attempting to figure out what happened to **Chandrayaan-2's Vikram** with the help of NASA's **Lunar Reconnaissance Orbiter (LRO)**.

### LUNAR RECONNAISSANCE ORBITER (LRO)

It is a **NASA mission to the moon within the Lunar Precursor and Robotic Program (LPRP)** in preparation for future manned missions to the moon and beyond (Mars). LRO is **the first mission of NASA's 'New Vision for Space Exploration'.**

**The objectives of LRO are to:**

- Identify potential lunar resources.
- Gather detailed maps of the lunar surface.
- Collect data on the moon's radiation levels.
- Study the moons polar regions for resources that could be used in future manned missions or robotic sample return missions.
- Provide measurements to characterise future robotic explorers, human lunar landing sites and to derive measurements that can be used directly in support of future Lunar Human Exploration Systems.

### 8.3.5 Chandrayaan 3

Chandrayaan 3 is launched on 14 July 2023 using a special rocket/launch vehicle known as the LVM3-M4 launcher. This mission comprised a lander and a rover. The lander for Chandrayaan-3 had only four thruster engines, unlike Vikram on Chandrayaan-2 which had five thruster with a fifth one being centrally mounted.

The rover for Chandrayaan-3, is similar to the Pragyan rover used in Chandrayaan-2. It features six wheels and derive its power from solar panels. Equipped with a range of scientific instruments such as a camera, spectrometer, and drill, the rover enables extensive exploration and analysis of the lunar surface.

The lander will touch down on the lunar surface near the south pole of the Moon, and the rover will subsequently embark on a 14-day exploration of the lunar terrain. (Refer **Infographic – Chandrayaan-3**)

***Challenges for Chandrayaan-3 Mission***

- Developing a Reliable and Safe Rover
- Securing the necessary funding for the mission
- Technical Complexity
- Schedule Adherence
- International Collaboration

Despite these challenges, ISRO is confident that it will successfully complete the Chandrayaan-3 mission, which will be a significant achievement for India. This mission will inspire a new generation of scientists and engineers and serves as a beacon of hope for the future of space exploration.

## 8.4 FUTURE SPACE MISSIONS OF INDIA

### 8.4.1 Aditya

ISRO is planning Aditya Mission to study Sun and to solve solar physics mysteries. The satellite will be launched during 2023 timeframe by PSLV-XL variants from Sriharikota. Aditya-1 was meant to observe only the solar corona. The outer layers of the Sun are termed as corona [(which extend to thousands of kilometres above the disc (photosphere)]. It has a temperature much higher than the solar disc temperature of around 6000 K (that is, the temperature of more than a million degree kelvin). We are yet to find reason of such higher temperature of the corona (a branch dealing with this is known as solar physics). The satellite is there to assist in determining the reason behind disturbance of

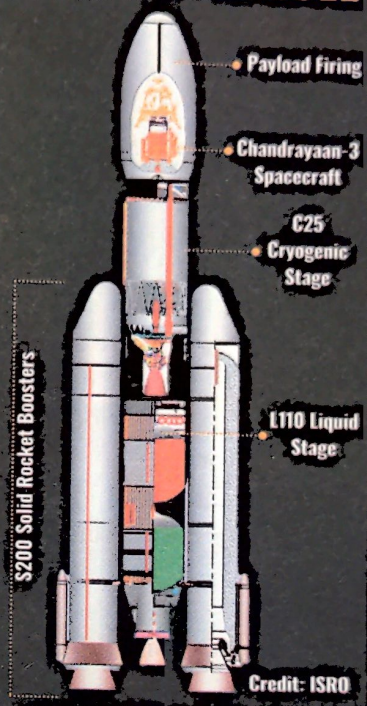
# CHANDRAYAAN-3
## MOON MISSION

### WHAT IS CHANDRAYAAN-3 MISSION?

- India is all set for its third lunar exploration mission called Chandrayaan-3.
- Launched on 14 July 2023 using a special rocket/launch vehicle known as the LVM3-M4 launcher.
- What makes this mission exciting is that ISRO (Indian Space Research Organization) is planning to achieve a soft landing on the Moon's surface with a special spacecraft. It's like gently placing something delicate on the Moon. They will also be testing a rover, which is like a small car, that can move around on the Moon's terrain.
- This will allow them to explore and study different areas of the Moon up close. The Chandrayaan-3 mission will not only help in advancing ISRO's future space missions but will also contribute to our understanding of the Moon.
- Scientists will conduct experiments directly on the lunar surface, gaining valuable insights and expanding our knowledge of the Moon.
- So, in simpler terms, ISRO is bringing the Moon closer to us by sending a mission to land softly and explore with a rover, all in an effort to learn more about our celestial neighbor.

Credit: ISRO

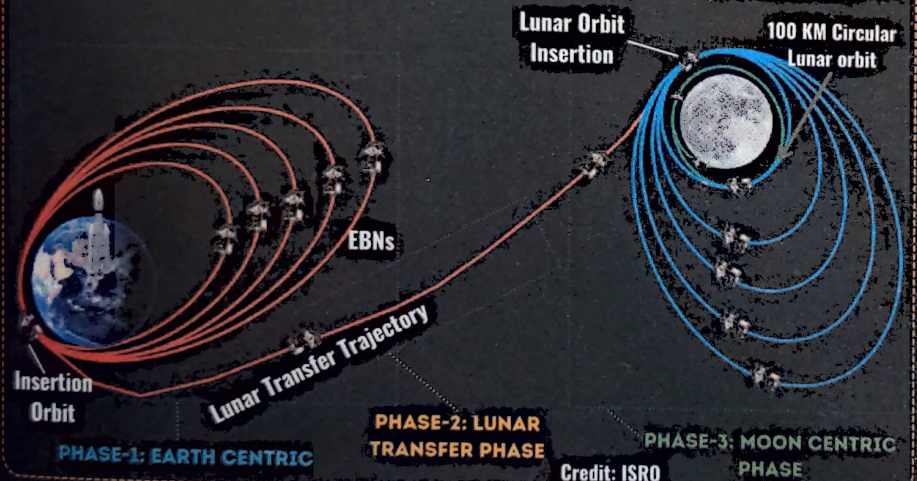
### LVM3-M4 VEHICLE




Credit: ISRO

- The LVM3 is ISRO's powerful rocket designed for carrying heavy payloads into space.
- It has an impressive track record of successfully completing six missions in a row.
- The upcoming launch will be the fourth operational flight of the LVM3 and its main objective is to launch the Chandrayaan-3 spacecraft into a specific orbit called the Geo Transfer Orbit (GTO).
- The LVM3 is not only India's largest but also its heaviest launch vehicle, capable of ferrying satellites from both India and international customers.
- In simpler terms, it's like a massive and robust vehicle built for the purpose of transporting large satellites into space.
- The successful completion of this mission will add to the LVM3's already remarkable legacy.

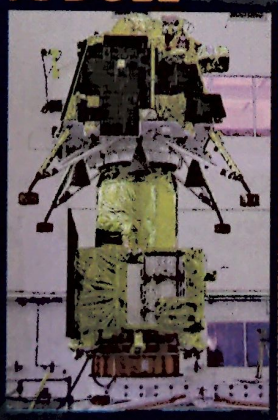
### TRAJECTORY & PHASES OF MISSION




Credit: ISRO

### PROPULSION MODULE

- Chandrayaan-3 is composed of three main components:
  - An indigenous propulsion module,
  - A Lander module
  - A Rover
- The propulsion module plays a crucial role in the mission.
  - It is responsible for transporting the lander module and the rover from the initial injection orbit to a lunar orbit approximately 100 kilometers above the Moon's surface.
  - Additionally, the propulsion module carries a payload called SHAPE (Spectro-polarimetry of Habitable Planetary Earth). This payload is designed to conduct spectral and polarimetric measurements of Earth from the lunar orbit.
- In simpler terms, the propulsion module is like the transportation system that carries the lander and rover from the point of launch into space to the moment when the lander is separated and begins its descent to the lunar surface. It also has a special instrument on board, SHAPE, which will gather important data about Earth from the Moon's orbit.



Credit: ISRO

### ROVER PAYLOADS

**APXS**
Alpha Particle X-Ray Spectrometer
The aim is to determine the chemical composition and mineralogy of the lunar surface, improving our understanding of it.

**LIBS**
Laser Induced Breakdown Spectroscope
To analyze the elemental composition (Mg, Al, Si, K, Ca, Ti, Fe) of lunar soil and rocks near the landing site.

### LANDER PAYLOADS

**RAMBHA-LP**
Langmuir Probe
The goal is to measure and track the density of ions and electrons in the plasma near the lunar surface.

**ChaSTE**
Chandra's Surface Thermophysical Experiment
The aim is to conduct measurements of the thermal properties of the lunar surface in the vicinity of the polar region.

**ILSA**
Instrument for Lunar Seismic Activity
The objective is to measure seismic activity in the area surrounding the landing site and analyze the structure of the lunar crust and mantle

communication networks and electronics on the Earth due to solar flares and solar winds.

### *Position of the Satellite*

In order to get the best science from the sun, continuous viewing of the sun is preferred without any occultation/ eclipses and hence, Aditya-L1 satellite will be placed in the halo orbit around the Lagrangian point 1 (L1) of the sun-earth system.

### *What are Lagrangian Points and Halo Orbit?*

Lagrangian points are the locations in space where the combined gravitational pull of two large masses roughly balance each other. Any small mass placed at that location will remain at constant distances relative to the large masses. There are five such points in Sun-Earth system and they are denoted as L1, L2, L3, L4 and L5. A halo orbit is a periodic three-dimensional orbit near the L1, L2 or L3.

As per technical studies, a PSLV-XL launcher would be able to place a satellite at a halo orbit around L1 point.

**WHAT IS HALO ORBIT?**

**How it works:** The Lagrange point is just an equilibrium point with no gravitational pull and hence, the spacecraft does not technically orbit the actual Lagrange point, instead the spacecraft in a halo orbit moves in a circular path around the Lagrange point. Halo orbits are the result of a complicated interaction between the gravitational pull of the two planetary bodies and the coriolis and centrifugal accelerations on a spacecraft.

The 1500 kg satellite will carry total seven payloads namely:

- **Visible Emission Line Coronagraph (VELC)**
- **Solar Ultraviolet Imaging Telescope (SUIT)**
- **Aditya Solar wind Particle Experiment (ASPEX)**
- **Plasma Analyser Package for Aditya (PAPA)**
- **Solar Low Energy X-ray Spectrometer (SoLEXS)**
- **High Energy L1 Orbiting X-ray Spectrometer (HEL1OS)**
- **Magnetometer**

This project, with the inclusion of multiple payloads, provides an opportunity to solar scientists from multiple institutions within the country to participate in space-based instrumentation and observations. Thus, the improved Aditya-L1 project will facilitate in the complete learning of the Sun's active processes and also deal with some of the solar physics' outstanding problems.

**ADITYA-L1 SUPPORT CELL**

- Aditya-L1 Support Cell is a community service centre that has been set up to bring all data on board India's first dedicated solar space mission to a single web-based interface.
- It is **a joint effort of Indian Space Research Organisation and Aryabhatta Research Institute of Observational Sciences.**
- It will allow every interested individual to perform scientific analysis of the data.

(Refer **Infographic – Aditya-L1 Mission**)

## 8.4.2 Gaganyaan Programme

The Union Cabinet has approved the Gaganyaan Programme with demonstration of Indian Human Spaceflight capability to low earth orbit for a mission duration ranging from one orbital period to a maximum of seven days. ISRO aims to launch its maiden **Human Space Mission**, Gaganyaan in 2024.

It is a first human space flight demonstration targeted to be completed within 40 months from the date of sanction. *India could potentially become the fourth country to send a man in space*, after the erstwhile ***USSR, the US and China***. India has already completed missions to the moon and Mars. GSLV Mk-III will be used to carry the orbital module which will have necessary provisions for sustaining a ***3-member crew for the duration of the mission***. Gaganyaan Programme will be a national effort in collaboration with Industry, Academia and other scientific agencies and laboratories as stake holders along with ISRO.

- Gaganyaan is an indigenous crewed orbital spacecraft that is intended ***to send 3 astronauts to space for a minimum of seven days by 2024***, as part of the Indian Human Space-Flight Programme.
- The human ***spaceflight will take 16 minutes to reach the orbit where it will stay for five to seven days.***
- The Indian space agency displayed the Gaganyaan crew model and orange space suits at the Bengaluru Space Expo's 6$^{th}$ edition earlier this year. ***The space***

# ADITYA-L1 MISSION

## The first observatory-class space-based solar mission from India

## About Aditya-L1

- Aditya-L1 is the **first space based observatory class Indian solar mission to study the Sun.**
- The spacecraft is planned **to be placed in a halo orbit around the Lagrangian point 1 (L1) of the Sun-Earth system,** which is about 1.5 million km from the Earth.
- A satellite placed in the halo orbit around the L1 point has the major advantage of continuously viewing the Sun without any occultation/ eclipse. This will provide a greater advantage of observing the solar activities continuously.
- **The spacecraft carries seven payloads to observe the photosphere, chromosphere, and the outermost layers of the Sun (the corona)** using electromagnetic and particle detectors. Using the special vantage point of L1, **4 payloads directly view the Sun** and the **remaining 3 payloads carry out in-situ studies of particles and fields at the Lagrange point L1.**
- The suit of Aditya-L1 payloads are **expected to provide most crucial information to understand the problems of coronal heating, Coronal Mass Ejection, pre-flare and flare activities, and their characteristics, dynamics of space weather, study of the propagation of particles, and fields in the interplanetary medium etc.**

## Major Science Objectives

- To understand the Coronal Heating and Solar Wind Acceleration.
- To understand initiation of Coronal Mass Ejection (CME), flares and near-earth space weather.
- To understand coupling and dynamics of the solar atmosphere.
- To understand solar wind distribution and temperature anisotropy.

## Uniqueness of The Mission

- First time spatially resolved solar disk in the near UV band.
- CME dynamics close to the solar disk (~ from 1.05 solar radius) and thereby providing information in the acceleration regime of CME which is not observed consistently.
- On-board intelligence to detect CMEs and solar flares for optimised observations and data volume.
- Directional and energy anisotropy of solar wind using multi-direction observations.

## Lagrange Points

- For a two body gravitational system, the Lagrange Points are the positions in space **where a small object tends to stay, if put there.**
- **These points in space for a two body systems such as Sun and Earth can be used by spacecraft to remain at these positions with reduced fuel consumption.** Technically at Lagrange point, the gravitational pull of the two large bodies equals the necessary centripetal force required for a small object to move with them.
- For two body gravitational systems, **there are total five Lagrange points denoted as L1, L2, L3, L4 and L5.**
- **The Lagrange point L1 lies between Sun-Earth line.** The distance of L1 from Earth is approximately 1% of the Earth-Sun distance.

## Trajectory of Aditya-L1

Aditya-L1 trajectory from Earth to L1

- The Aditya-L1 mission will be launched by **ISRO PSLV rocket** from **Satish Dhawan Space Centre SHAR (SDSC SHAR), Sriharikota.** Initially the spacecraft will be placed in a **low earth orbit.**
- Subsequently, the orbit will be made more elliptical and later the spacecraft will be **launched towards the Lagrange point L1** by using on-board propulsion.
- As the spacecraft travels towards L1, it will exit the earths' gravitational Sphere of Influence (SOI). After exit from SOI, the cruise phase will start and subsequently the spacecraft will be injected into a large halo orbit around L1.
- The total travel time from launch to L1 would take about four months for Aditya-L1.

*suits were developed at Vikram Sarabhai Space Centre, Thiruvananthapuram.*

- The **capsule will rotate around the Earth every 90 minutes**, and astronauts will be able to witness sunrise and sunset. The three astronauts will be able to see India from space every 24 hours, while they conduct experiments on micro-gravity.
- Approximately, ***₹10,000-crore mission will be a turning point in India's space journey.*** ISRO has developed some critical technologies like re-entry mission capability, crew escape system, crew module configuration, thermal protection system, deceleration and flotation system, sub-systems of life support system required for Mission Gaganyaan.

**ISRO CONDUCTED PAD ABORT TEST**

- In 2018, the ISRO undertook a first '**pad abort test**' significant for a future human space mission. The pad abort test experiments the crew module safe recovery in case of any exigency at the launch pad.
- PAT (pad abort test) is the first of the test in a series for qualifying **a technology of crew escape system in future relating to a manned mission. Crew escape system is a measure for emergency escape** which assists to quickly pull the astronaut cabin along with crew out to a safer distance from launch vehicle during a launch abort.

ISRO successfully conducted its first 'pad abort test' which seems to be its preparation for the Gaganyaan mission. **The pad 'abort' test** or **Crew Escape System is a measure for emergency escape** which will assist to pull the crew out from the launch vehicle during the abortion of a mission. The test, was undertaken at the Satish Dhawan Space Centre, Sriharikota. The Pad Abort Test experiments the crew module safe recovery in case of any exigency at the launch Pad.

**Indian Space Research Organisation (ISRO) and Russia's Roscosmos State Corporation for Space Activities (ROSCOSMOS) have signed an MoU for working jointly on Gaganyaan.**

**According to the MoU, the Indian astronaut is offered a ride by the ROSCOSMOS, a short visit on board Soyuz spacecraft to International Space Station (ISS) in 2023–2024 for a small training mission.**

### *Flight Schedule in Three Phases*

- **Phase 1 (2023):** Uncrewed Spacecraft Flight Test
- **Phase 2 (2023–2024):** Uncrewed Spacecraft Flight Test + Vyommitra
- **Phase 3/Final Phase (2024):** Crewed Spacecraft

Test vehicle flight for the validation of Crew Escape System performance and the first uncrewed mission of Gaganyaan (G1) are scheduled during 2023.

After that second uncrewed mission is scheduled to be launched at the end of 2023 or beginning of 2024, which will be carrying "Vyommitra", a spacefaring human robot developed by ISRO and finally the first crewed Gaganyaan mission in 2024.

(Refer **Infographic – Mission Gaganyaan**)

### *Major Collaborating Partners for Gaganyaan include*

1. Indian Armed Forces;
2. Defence Research Development Organization;
3. Indian maritime agencies – Indian Navy, Indian Coast Guard, Shipping Corporation of India, National institute of Oceanography;
4. National Institute of Ocean Technology;
5. Indian Meteorological Department;
6. CSIR Labs;
7. Academic Institutes;
8. Industry Partners

### *Creation of Gaganyaan National Advisory Council*

Gaganyaan National Advisory Council was created in 2019 with members from different institutions and industries.

### *Human Space Flight Centre (HSFC)*

Human Space Flight Centre (HSFC) is created to carry out the activities related to human spaceflight. **HSFC shall be responsible for the implementation of Gaganyaan.** The project involves mission planning, development of engineering systems for **crew survival in space, crew selection and training and also pursue activities for sustained human space flight missions. HSFC will take the support of ISRO centres** to implement the first developmental [crewed] flight.

### *Contribution of DRDO for Gaganyaan Mission*

ISRO, DRDO sign MoU to provide critical technologies for **Human Space Mission**. Under the agreement, the technological capabilities existing in DRDO labs for defence applications will be customised to meet the

# Mission Gaganyaan

## About Gaganyaan

- Gaganyaan project envisages demonstration of human spaceflight capability by launching crew of 3 members to an orbit of 400 km for a 3 days mission and bring them back safely to earth, by landing in Indian sea waters.
- Various precursor missions are planned for demonstrating the Technology Preparedness Levels before carrying out the actual Human Space Flight mission. These demonstrator missions include Integrated Air Drop Test (IADT), Pad Abort Test (PAT) and Test Vehicle (TV) flights. Safety and reliability of all systems will be proven in unmanned missions preceding manned mission.

## LAUNCH VEHICLE HUMAN RATED LVM3 (HLVM3)

- LVM3 rocket - The well proven and reliable heavy lift launcher of ISRO, is identified as the launch vehicle for Gaganyaan mission. It consists of solid stage, liquid stage and cryogenic stage.
- All systems in LVM3 launch vehicle are re-configured to meet human rating requirements and christened Human Rated LVM3.
- HLVM3 will be capable of launching the Orbital Module to an intended Low Earth Orbit of 400 km.
- HLVM3 consists of Crew Escape System (CES).

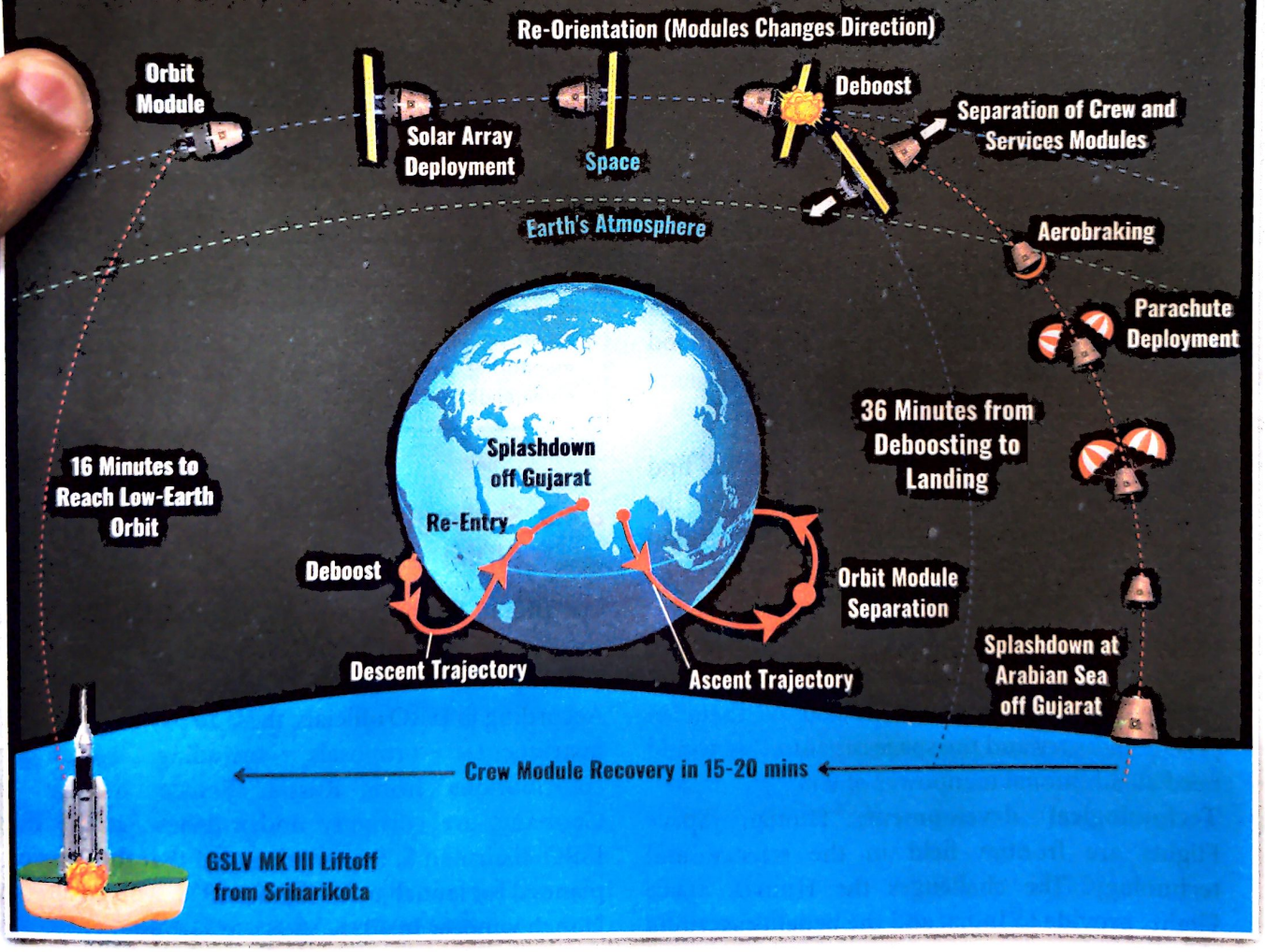
Credit: ISRO

## ORBITAL MODULE

- Orbital Module (OM) that will be Orbiting Earth comprises of Crew Module (CM) and Service Module (SM).
- OM is equipped with state-of-the-art avionics systems with adequate redundancy considering human safety.
- CM is the habitable space with Earth like environment in space for the crew.
- It is of double walled construction consisting of pressurized metallic Inner Structure and unpressurised External Structure with Thermal Protection System (TPS).
- SM will be used for providing necessary support to CM while in orbit.
- It is an unpressurized structure containing thermal system, propulsion system, power systems, avionics systems and deployment mechanisms.

Crew Module: Habitat of Astronaut

Service Module: Does on-orbit Servicing



requirements of ISRO's human space mission. DRDO will be providing critical technologies to ISRO such as space crew health monitoring and emergency survival kit, space food, parachutes for the crew module's safe recovery and radiation measurement and protection.

*Objectives of the Mission*

- Enhancement of science and technology levels in the country.
- A national project involving several institutes, academia and industry.
- Improvement of industrial growth.
- Inspiring youth
- Development of technology for social benefit
- Improving international collaboration

*Challenges of Gaganyaan Programme*

- **Gravity field:** Transitioning from one gravity field to another is tricky. It affects hand-eye and head-eye coordination.
- **Isolation:** In spite of providing well training to astronauts, behavioural issues may crop up. They may encounter depression, sleep and psychiatric disorders, etc.
- **Radiation:** In space stations, astronauts receive over ten times the radiation than what people are subjected to on Earth. It may increase the risk of cancer, etc.
- **Hostile environment:** Space is hostile.
- In addition to lack of gravity and danger of radiation, there is no atmosphere. Human blood starts boiling if there is no pressure.

*Relevance of a Manned Space Mission for India*

- **Boost to industries:** The Indian industry will find large opportunities through participation in the highly demanding space missions. Gaganyaan Mission is expected will source nearly 60% of its equipment from the Indian private sector.
- **Employment:** According to the ISRO chief, the Gaganyaan mission would create 15,000 new employment opportunities, 13,000 of them in private industry and the space organisation would need an additional manpower of 900.
- **Technological development:** Human Space Flights are frontier field in the science and technology. The challenges the Human Space Flights provide to India, and the benefits accruing from taking up those missions will be very high and will lead to further thrust for technological developments in India.
- **Spurs research and development:** It will boost good research and technology development. With a large number of researchers with proper equipment involved, HSF will thrust significant research in areas such as materials processing, astrobiology, resources mining, planetary chemistry, planetary orbital calculus and many other areas.
- **Motivation:** Human space flight will provide that inspiration to the youth and also the national public mainstream. It would inspire young generation into notable achievements and enable them to play their legitimate role in challenging future activities.
- **Prestige: India will be the fourth country to launch human space mission.** The Gaganyaan will not only bring about prestige to the nation but also establish India's role as a key player in the space industry.

**VYOM MITRA**

It is ISRO's ***first woman astronaut.*** Vyommitra, equipped with a head, two arms and a torso, is built to ***mimic crew activity inside the crew module of Gaganyaan.***

It is capable of attaining launch and orbital postures, responding to the environment, generating warnings, replacing carbon dioxide canisters, operating switches, monitoring of the crew module, receiving voice commands, responding via speech (bilingual).

### 8.4.3 Shukrayaan Mission/Venus Orbiter Mission (VOM)

The **Indian Space Research Organisation (ISRO)** has short-listed **20 space-based experiment** proposals for its proposed Venus orbiter mission '**Shukrayaan-1**'. According to ISRO officials, these 20 payloads (scientific instruments) proposals, including collaborative contributions from Russia, France, Sweden and Germany, are currently under review, at the ISRO. ISRO chairman S. Somanath stated that the mission is planned for launch in December 2024, with an alternate launch window in 2031.

***Key Points***

- It is a mission to study Venus for more than four years.
- **Scientific objectives:** Investigation of the surface processes and shallow subsurface stratigraphy; and solar wind interaction with Venusian Ionosphere, and studying the structure, composition and dynamics of the atmosphere.
- **Its expected launch mass will be around 2500 kg.**
- **The satellite** is planned to be launched onboard **GSLV Mk II rocket.**
- **The proposed orbit** is expected to be around 500 × 60,000 km around Venus. This orbit is likely to be reduced gradually, over several months to a lower apoapsis (farthest point).

**WHY STUDY VENUS?**

- Venus is often described as **the "twin sister" of the Earth** because of the similarities in size, mass, density, bulk composition and gravity.
- It is believed that both planets share a common origin, forming at the same time out of a condensing nebulosity around 4.5 billion years ago.
- Venus is around **30% closer to the Sun as compared to Earth resulting in much higher solar flux.**

## FUTURE MISSIONS OF INDIA

***Gaganyaan*** is an Indian crewed orbital spacecraft (jointly made by ISRO and HAL) intended to be the basis of the Indian Human Spaceflight Programme. The spacecraft is being designed to carry three people, and a planned upgraded version will be equipped with rendezvous and docking capability.

Lunar Polar Exploration Mission is a concept mission by JAXA and ISRO to explore the south pole region of the Moon in 2025. The mission concept has not yet been formally proposed for funding and planning.

Aditya-L1 is the first Indian Solar Coronagraph spacecraft mission to study solar corona in visible and near IR bands.

After GAGANYAAN Project ISRO will start its work those will launch successfully by 2035 with approx. 20 ton mass.

NASA-ISRO Synthetic Aperture Radar (NISAR) is a joint project between NASA and ISRO to co-develop and launch a dual-frequency synthetic aperture radar satellite to be used for remote sensing. It is notable for being the first dual-band radar imaging satellite.

**Mars Orbiter Mission 2 (MOM 2)** also called ***Mangalyaan 2*** is India's second interplanetary mission planned for launch to Mars by the Indian Space Research Organisation (ISRO) in the 2021–2024 time frame. It will consist of an orbiter, and will not include a lander and a rover.

The **Indian Venusian orbiter mission** is a planned orbiter to Venus by the Indian Space Research Organisation (ISRO) to study the atmosphere of Venus.

## 8.5 WORLD'S GPS: NAVSTAR, GLONASS

GPS is a satellite-based navigation system enabling the accurate position of the user on a map. It is extremely useful in marking the positions for an aircraft, submarine, or even an individual. To provide the accurate location, direction, speed, and time, it uses a group of 18 to 36 satellites. As of 2018, only the American **NAVSTAR (Navigation Satellite and Ranging)**, **Russian GLONASS (Global Navigation Satellite System)** and **China (Beidou/COMPASS)** are fully operational globally. Other big countries like **EU (GALILEO)**, France, etc., are expanding their regional navigational systems, and are expected to be globalised in coming years. **NAVSTAR is the world's first GPS.** It has 31 satellites to itself with an accuracy of 3.5 to 7.8 metres. GLONASS, on the other hand, has 24 satellites operational at present (accuracy of 5 to 10 metres). GPS technology is not only used for navigation purpose but also for various other applications like operation of mobile phone in various banking operation, powergrid controls etc. Certain Countries have own regional GPS like **Japan (Quasi-Zenith Satellite System)** and **India (Gagan and IRNSS – Indian Regional Navigation Satellite System / NavIC – Navigation Indian Constellation).**

**BeiDou/COMPASS**

**China completed its BeiDou Navigation Satellite System constellation in June 2020.**

- It is Chinese Satellite Navigation System. The system uses a network of satellites and can **provide positional accuracies of under ten metres (GPS provides positioning accuracies of under 2.2 metres).**
- **China initiated BeiDou in 1994** with aims to integrate its application in different sectors, including **fishery, agriculture, special care, mass-market applications, forestry and public security.**
- BeiDou offers services including **accurate positioning, navigation and timing as well as short message communication.**

**How many satellites are there in the system?**

It consists of **27 satellites in medium Earth orbit, 5 in geostationary orbit and 3 in inclined geosynchronous orbits.**

## 8.6 INDIA'S REGIONAL LEVEL GLOBAL POSITIONING SYSTEM (GPS)

### 8.6.1 GPS Aided Geo-Augmented Navigation Satellite System (GAGAN)

GAGAN is a **satellite based on augmentation system (SBAS).**

It is the Airport Authority of India's first step towards introduction of modern communications and positioning system over Indian airspace, which included surveillance and air traffic management, enabling pilots to navigate in the Indian airspace with an accuracy of 3 metres. So far, three satellites are dedicated to this project.

**GSAT 8 (21 May 2011), GSAT 10 (29 September 2012)** with 12 Ku-band, 12 C-band, and 12 extended C-band transponders along with a GAGAN payload, and **GSAT 15 (11 November 2015)** with full India coverage by 24 Ku-band transponders and a GAGAN payload are the three satellites that made GAGAN a successful project. It is advantageous over the conventional radar-based system used by most of the world because of its precision.

### 8.6.2 Indian Regional Navigation Satellite System (IRNSS)

Having a global navigation system bolsters the ability of a nation to serve as ***a net security provider,*** especially through the guarantee of such assurance policies. It can also play a significant role in relief efforts post disasters such as the tsunami in the Indian Ocean region in 2004 and the Pakistan-India earthquake in 2005.

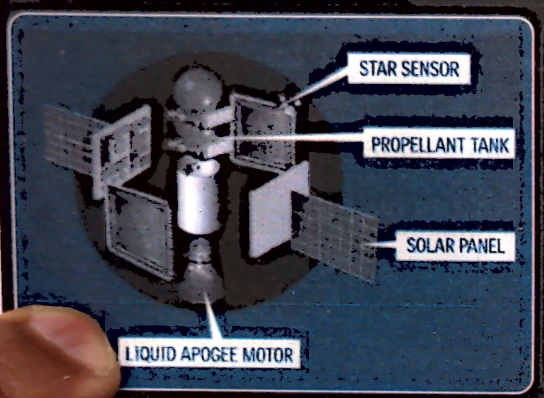
(Refer **Infographic – IRNSS – Indian Regional Navigation Satellite System**)

Note: ***Qualcomm Technologies*** has unveiled mobile chipsets supporting ***the Indian regional satellite navigation system – NavIC (Navigation in Indian Constellation).*** The release of chipsets will help accelerate the adoption of NavIC by smartphone Original Equipment Manufacturers (OEMs). The OEMs can now release any new models for the Indian market which are NavIC enabled, thus eventually making NavIC as a standard feature in the upcoming handsets, applications, processors, etc.

# IRNSS: INDIAN REGIONAL NAVIGATION SATELLITE SYSTEM

## About IRNSS

- An **autonomous regional navigation satellite system as developed by ISRO** is IRNSS, which would be under the control of Indian government.
- The access to GPS (for instance, access to foreign government-controlled global navigation satellite systems is not guaranteed in hostile situations, as happened to the Indian military depending on American GPS during the Kargil War) is not guaranteed under hostile situations and it drove the need of such navigation system.
- This project was **approved by GOI in May 2006.**
- **Covering an area of about 1,500 kilometers around India**, it will provide **20-metre accuracy over the Indian Ocean region** and **10-metre accuracy over India and adjacent countries.**
- Such resolution will be useful as it keeps track of safety of India at bordering areas to detect movement of troops, terrorist activity, etc., from neighboring countries; the resolution of IRNSS is of immense use.
- **3 extremely accurate Rubidium Atomic Clocks in each satellite.**
- GPS Receivers will not work; they need special receivers.




## Types of Services Provided By IRNSS

- **Standard Positioning Service (SPS)** – for civilian uses
- **Restricted Service (RS)/Precision Positioning System** – an encrypted one

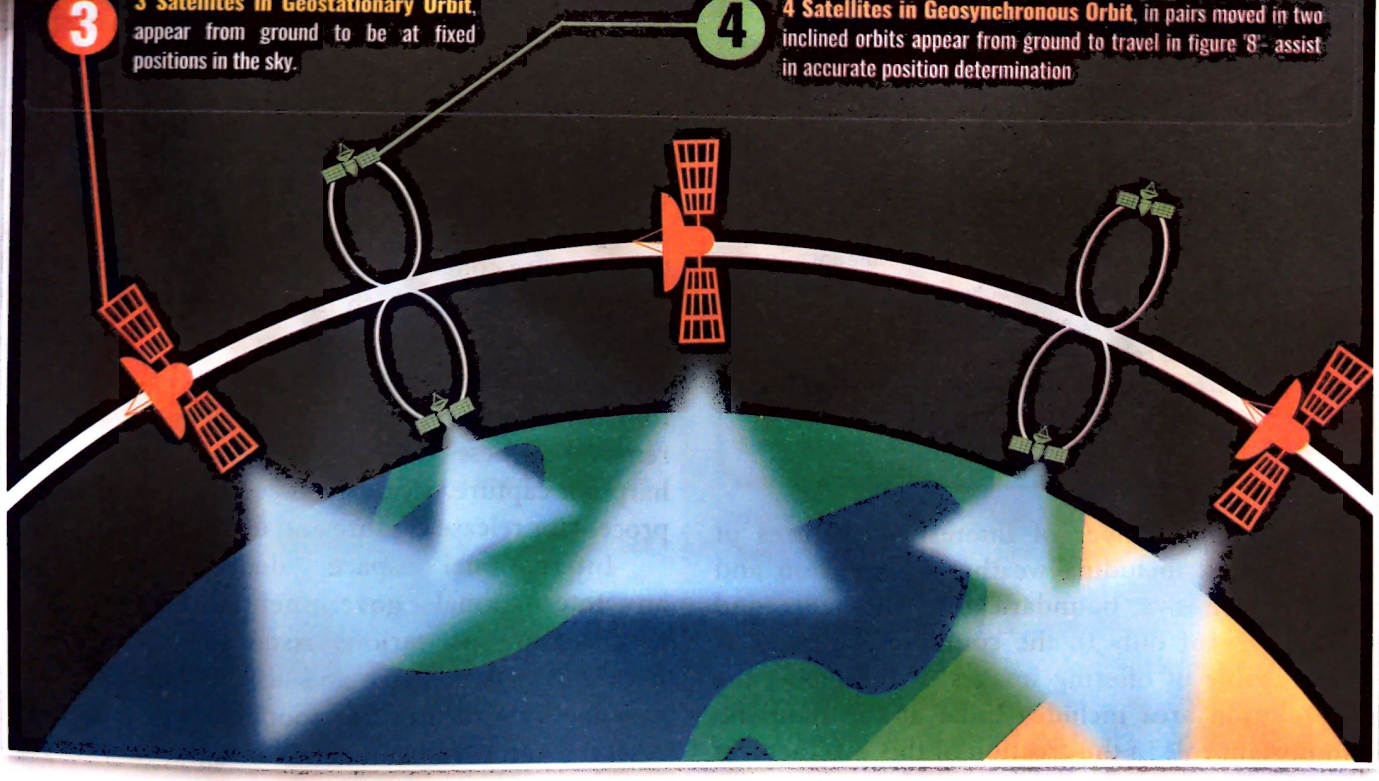
## NavIC Applications include:

1. Terrestrial, aerial and marine navigation
2. Disaster management
3. Vehicle tracking and fleet management
4. Integration with mobile phones
5. Precise timing
6. Mapping and geodetic data capture
7. Terrestrial navigation aid for hikers and travelers
8. Visual and voice navigation for drivers

## Satellites in IRNSS-7

**3** **3 Satellites in Geostationary Orbit**, appear from ground to be at fixed positions in the sky.

**4** **4 Satellites in Geosynchronous Orbit**, in pairs moved in two inclined orbits appear from ground to travel in figure '8' assist in accurate position determination



## 8.7 BHUVAN

Bhuvan is an application developed by ISRO providing medium to high-resolution satellite imagery of virtually entire India over the Internet. On 12 August 2009, a prototype of this application was launched.

With spatial resolutions ranging from 10–100 metres, Bhuvan will offer superior imagery of Indian locations, as compared to other Virtual Globe software, such as Google and Wikimedia. The locations can be viewed from different perspectives and this will enable measurement of distances. The portal is designed to run on slow Internet connections and for security concerns, the imagery would steer clear of all sensitive military installations in India.

**ISRO ANNOUNCES 'BHUVAN'**

The Department of Space (DoS), under which ISRO comes, signed an MoU with **geospatial technology company CE Info Systems Pvt Ltd on 11 February 2021.**

- The collaboration will enable them to jointly identify and build a holistic **geospatial portal** utilising earth observation datasets, **'NavIC', Web Services and APIs (application programming interface) available in MapmyIndia.**
- The geospatial portals will be called **'Bhuvan', 'VEDAS' and 'MOSDAC'.**

**Key Facts**

**Bhuvan** is the national geo-portal developed and hosted by ISRO comprising geospatial data, services, and tools for analysis.

**VEDAS** (Visualisation of Earth observation Data and Archival System) is an online geo-processing platform that uses optical, microwave, thermal and hyperspectral data covering applications particularly meant for academia, research and problem solving.

**MOSDAC** (Meteorological and Oceanographic Satellite Data Archival Centre) is a data repository for all the meteorological missions of ISRO and deals with weather-related information, oceanography and tropical water cycles.

There are a number of interesting features of Bhuvan images, including weather information and even administrative boundaries of all states and districts, relevant only to the country. Though it is equally capable of offering images of the globe, the best resolution area includes India at the moment. The important role in the creation of this product was played by **National Remote Sensing Agency (NRSA).** The data provided by Satellites like Resourcesat-I, Cartosat-I and Cartosat-II has been used by ISRO to get the best possible imagery for India.

## 8.8 KESSLER SYNDROME/SPACE JUNK CONCEPT

The Kessler Syndrome/Kessler Effect/Collisional Cascading concept was proposed by NASA scientist Donald J. Kessler in 1978. It is a scenario in which the density of objects in Low Earth Orbit (LEO) is increasing due to various collisions among objects and further a cascade of collision generates more and more of space debris. Every satellite, space probe and manned mission have the potential to produce a lot of space debris. There were about 2,000 commercial and government satellites orbiting the Earth, according to 2014 report. On an average, one satellite is destroyed each year. Now we have an estimation of six lakh pieces of space junk ranging from 1 cm to 10 cm in space. We have not yet adopted any procedure to solve this debris problem from space. In coming future they can lead to various problems in human life and will also be a congestion to launch satellites at proper orbit. In a movie, Gravity, space debris collision to a space shuttle is observed. This collision is dangerous and can destroy astronauts' life in space and also can harm to working satellites in space.

### *The Remove Debris Mission Soon*

This mission was brought by University of Surrey, UK. The target of this mission is to clean about 7,000 tonnes of active space debris of old satellites and spacecrafts and spent rocket parts orbiting Earth. More debris could lead to more collisions – a cascade effect known as the Kessler Syndrome, which may render space eventually inoperable for important services like navigation, communications, weather forecasting, etc. According to many reports, four methods may be applied for the removal of these space debrises – such as net capture, harpoon capture, vision-based navigation, de-orbiting process for release capture and deorbit.

International space debris committee is an international governmental forum for the coordination of various issues of man-made and natural debris in space and also involves to facilitate various opportunities for cooperation in space debris research and involve in debris mitigation options.

### *India & Space Debris*

Aiming to develop a method **to predict collision from space debris**, Indraprastha Institute of Information Technology (IIIT), Delhi, has received research funding from **the National Super Computing Mission (NSM)**, implemented by the department of science and technology (DST). The project titled '**Orbit computation of Resident Space Objects for Space Situational Awareness**' has to be completed in two years.

Space debris poses a global threat to the continued use of space-based technologies that support critical functions like communication, transport, weather and climate monitoring, remote sensing.

- Predicting collision probability from these space objects is crucial from the national security perspective as well as for the protection of public and private space assets of Indian origin.

### *Space Debris in Space*

- The real amount of space debris is said to be between 500,000 and one million pieces as current sensor technology cannot detect smaller objects. They all travel at speeds of up to 28,162 kmph fast enough for a relatively small piece of orbital debris to damage a satellite or a spacecraft.

### *Significance of the Project*

- Outcome of this project will directly support the Indian space sector, valued at ₹51,334 crore by providing an operationally flexible, scalable, transparent and indigenous collision probability solution.

**NETRA**

- To safeguard its space assets from space debris, **ISRO had set up a dedicated Space Situational Awareness (SSA) Control Centre named "Netra"** in Bengaluru last December.
- Netra's key objective is to monitor, track and protect the national space assets and function as a hub of all SSA activities.
- Only the US, Russia and Europe have similar facilities in place to track space objects and share collision warnings.

## 8.9 PROBLEMS FACED BY ASTRONAUTS IN SPACE

The human body is uniquely designed to survive in Earth's gravity. In space, there is microgravity environment, which requires the human body to be adapted accordingly. There, astronauts need to float rather than walk in different parts of the spacecraft. This implies that the weight-bearing bones (those in the lower part of the body – the legs, hips and spine) experience a significant decrease in load bearing. This reduction leads to bone breakdown, releasing calcium that is reabsorbed by the body, leaving the bones more brittle and weak. There are fewer loads on the leg muscles and back muscles used for posture, during an extended spaceflight. Consequently, the muscles can begin to weaken or atrophy, subsequently leading to fall-related injuries and accidents during exploration missions. Currently, to overcome such issue, there is an exercise programme, but sooner nutritional interventions designed to reduce the muscle loss may be added as a complement to the spacecraft missions.

In space, there is no gravity to distribute the blood and other body fluids to the lower part of the body, especially the legs. This leads to redistribution of body fluids to the upper part of the body and away from the lower extremities. Due to this fluid shift, astronauts may experience puffy face and also a feeling of congestion.

In microgravity environment, the heart does not have to work hard and over time it gets deconditioned and decreases in size. Space radiation may affect endothelial cells, the lining of blood vessels, which might initiate or accelerate coronary heart disease.

The brain receives and interprets information from numerous sense organs, particularly the eyes, inner ear vestibular organs and deep senses from muscles and joints. An integrated set of neural circuits allows humans to maintain balance on Earth. The inner ear no longer functions as designed. During their stay in space, the body of astronauts adapt and hence when they return to Earth, they may experience problems standing up, stabilising their gaze, walking and turning. These disturbances are more profound with increase in microgravity exposure. The changes can affect operational activities including approach and landing, docking, remote manipulation, extra-

vehicular activity and post landing normal and emergency egress. On top of this, the exploration crews will have to shift their 'body clocks' from Earth's day/night cycle to that of their destination. By improving spacecraft lighting, sleep schedules and scheduling of work shift, such changes can be countered.

## 8.10 EXTRA VEHICULAR ACTIVITY/ SPACEWALK

Extra-Vehicular Activity (EVA) is the only activity performed ahead of the Earth's substantial atmosphere outside the spacecraft by an astronaut or a cosmonaut. The term generally refers to a spacewalk done external to a craft, which is orbiting the Earth. The cosmonauts have also undertaken deep-space Extra Vehicular Activities for retrieving film canisters from the exterior of the spacecraft on returning to Earth on each last of these three undertaken missions. In the year 1973, EVA was used in repairing of the launch damage to skylab, which is the US's first space station.

EVAs may be either tethered (the astronaut is connected to the spacecraft; oxygen and electrical power can be supplied through an unbiblical cable, no propulsion is needed to return to spacecraft) or untethered (here, astronaut are not connected to shuttle for life support system). Russia, US and China have demonstrated the capability to conduct an EVA.

The first EVA in deep space was made on August 1971 by American Al Worden to retrieve a film and data-recording canister from the Apollo 15 service module on return trip from the Moon.

American Bruke Mc Candless made his first journey with untethered EVA on 7 February 1984 during challenger mission STS-41B, using the Manned Maneuvering Unit.

First woman to perform an EVA was soviet Svellana Savitskaya, on 25 July 1984 while aboard the Salyut 7 space station. Her EVA lasted 3 hours 35 minutes.

## 8.11 INTERNATIONAL SPACE STATION

It is an internationally developed research facility in space in Low Earth Orbit. This place has a microgravity environment in which astronauts conduct experiments in biology, human biology, astronomy, physics and meteorology. It is a unique environment for the testing of the spacecraft systems that will be required for missions to the Moon and Mars. International Space Station is a complete home to the humans beyond the Earth. It is the most expensive object ever constructed by man.

### *Major Experiments*

- It observes effects of long-term space exposure on the human body.
- It is a place for ultrasound scans, various diagnosis and treatment of medical conditions in space.
- It will also be helpful in the study of near-weightless and microgravity environment and observe the evolution, growth, development, and internal processes of plants and animals.
- Investigation of superconductivity and the physics of fluids in microgravity will also open doors for various researches. This place will be also very helpful for the study of cosmic rays, cosmic dust, antimatter and dark matter in the universe.

The ISS is the ninth space station to be developed by crews, following the Soviet and later Russian Salyut, Almaz and Mir stations as well as Skylab from the US. After the US Space Shuttle programme ended in 2011, Soyuz rockets became the only provider of transport for astronauts at the International Space Station.

The ISS programme is a joint project among five participating space agencies: **NASA (USA), Roscosmos (Russia), JAXA (Japan), ESA (Europe)** and **CSA (Canada).**

International Space Station is divided into two sections, the **Russian Orbital Segment (ROS)** and the **United States Orbital Segment (USOS)**, which is shared by many nations. As of January 2014, the American portion of ISS is being funded until 2024 and Roscosmos has also endorsed the continued operation of ISS through 2024, but has proposed for the construction of a new Russian space station termed as **OPSEK**.

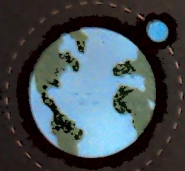
The Russian sources declared on 28 March 2015 that Roscosmos and NASA have decided to collaborate for developing the current ISS replacement. Later on, NASA publicised a secured statement conveying thanks for Russia's interest in exploration of space in future co-operation.

[Refer **Infographic – International Space Station (ISS)**]

# INTERNATIONAL SPACE STATION

## About ISS

- The International Space Station is a large spacecraft in orbit around Earth.
- It serves as a home where crews of astronauts and cosmonauts live.
- The space station is also a unique science laboratory.
- Several nations worked together to build and use the space station.
- The space station is made of parts that were assembled in space by astronauts.
- It orbits Earth at an average altitude of approximately 250 miles. It travels at 17,500 mph. This means it orbits Earth every 90 minutes.
- The first piece of the International Space Station was launched in **November 1998**. The **first crew** reached the station on **November 2, 2000**.
- The space station has the volume of a five-bedroom house or two Boeing 747 jetliners. It is able to **support a crew of six people, plus visitors.**

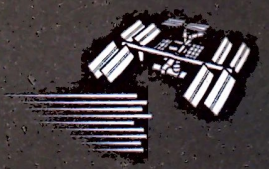


ORBITS EARTH AT AN ALTITUDE OF **370 KM**

## AMBITIOUS INTERNATIONAL COLLABORATIONS

CIRCLES THE GLOBE EVERY **90 MINUTES**

MOVES AT SPEED OF



**28,000 KM/H**

International Space Station

## BENEFITS FOR HUMAN

- Advanced Robotic Surgery
- Clean Drinking Water
- Remote Medical Diagnostics
- Educational Events

Microgravity and Low Earth Orbit **RESEARCH LABORATORY**

Conducting Experiments in

- Human Research
- Physical Sciences
- Astrophysics
- Life Sciences
- Earth Sciences
- Technology Research

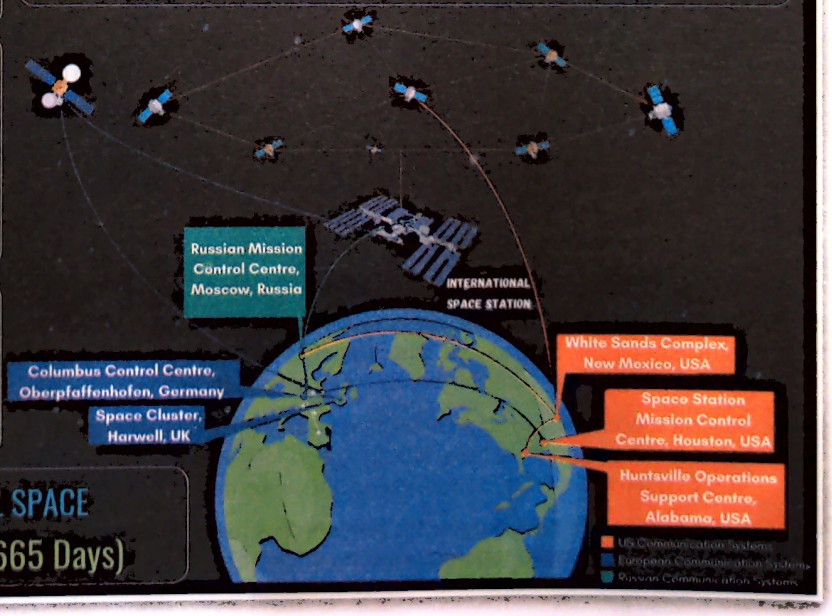
HAS A PERMANENT CREW OF **3 TO 6 PEOPLE**

FIRST HUMANS TO RESIDE ON THE ISS?

Cosmonauts Sergei Krikalev and Yuri Gidzenko

NASA Astronaut Bill Shepherd

MOST TIME SPENT ON THE INTERNATIONAL SPACE STATION (WOMEN) Peggy Whitson (665 Days)


Russian Mission Control Centre, Moscow, Russia
INTERNATIONAL SPACE STATION
White Sands Complex, New Mexico, USA
Columbus Control Centre, Oberpfaffenhofen, Germany
Space Cluster, Harwell, UK
Space Station Mission Control Centre, Houston, USA
Huntsville Operations Support Centre, Alabama, USA
US Communication Systems
European Communication Systems
Russian Communication Systems

## 8.12 SPACE HISTORY

| Year | Achievements |
|---|---|
| 1942 | In 1942, the first rocket, designed by Wernher Von Braun, who later worked with NASA as the creator of the rockets that went to the moon. |
| 1947 | The first animals were launched into space in 1947. To study the effects of space travel on animals, fruit flies were used. Since they are more similar to humans than we may imagine, they were chosen for the purpose. The flies had supply of corn to eat while travelling on the flight. |
| 1949 | The first monkey in space, was Albert II, a Rhesus monkey, a type of monkey, originally hailing from Asia. On 14 June 1949, Albert went into the space in a specially adapted American V2 rocket, that flew to a height of 83 miles from Earth. |
| 1957 | On 4 October 1957, Sputnik 1 was launched as the first satellite into space, marking the beginning of the space age. Sputnik was the first satellite to orbit around the Earth. |
| 1957 | The Russian space dog Laika was the first animal to orbit the Earth in a spacecraft known as Sputnik II, in November 1957. Laika means "Barker" in Russian, and through her mission, scientists could understand whether people could survive in space. |
| 1959 | Both American and Russian scientists were in a race to get a spacecraft to the Moon, in the year 1959; and Russians won the race. Space probe Luna II crash-landed onto the Moon at such a speed that would kill an astronaut if one had been travelling in it! So, it was ten more years later that the Moon's surface was visited by a human. |
| 1961 | The first man in space was Russian cosmonaut Yuri Gagarin on 12 April 1961. Gagarin's spacecraft, Vostok I, completed one orbit of the Earth, and landed about two hours after launch. With Vostok I, designed to crash land, Gagarin had to bail out and land using his parachute. |
| 1963 | Valentina Tereshkova was the first woman in space and she was a Russian cosmonaut. After her 1963 mission, Valentina became an important member of the Russian Government. She has been awarded many honours and prizes appreciating her achievements. A crater on the far side of the Moon is named after her. |
| 1966 | US President John F. Kennedy promised the world, in 1963, that the US would land men on the Moon before 1970. Before risking people's lives, a robot spaceship was sent by NASA, to make sure they could land safely. It was called Surveyor I, and the second soft landing on the Moon was made on 30 May 1966, a few months after the successful landing of Russian probe Luna IX. |
| 1966 | After landing on the Moon, the robotic spaceship Surveyor I started taking photographs of the Moon's surface, which it transmitted back to excited scientists in America and around the world. This vital information about the terrain enabled the scientists to work out how they might land people on the moon safely. |
| 1969 | Neil Armstrong, and then Buzz Aldrin took "one small step" and became the first men on the Moon, on 20 July 1969. The first words said on the moon were "the Eagle has landed". Their spaceship, Apollo XI worked perfectly, flying them 250,000 miles to the Moon, and they were brought safely to Earth by it. Buzz was a childhood nickname – his real name was Edwin. |
| 1970 | Two days into its journey to the Moon, on 13 April 1970, Apollo 13 suffered an explosion due to a wiring fault. With the help of whatever available resources were on board, NASA scientists and the astronauts on board improvised repairs to bring the crippled spaceship home. The mission was a successful failure: because although the crew never walked on the moon, at least they made it home alive! |
| 1971 | American astronauts on their fourth, fifth and sixth Apollo missions enjoyed use of a Moon car to explore the Moon from 1971. Known as the Lunar Rover, it was electric powered, and had a top speed of 8 mph (miles per hour). |
| 1973 | In 1973, Russian space probe Mars II explored Mars, the fourth planet of the solar system. The probe was made of two parts. One part stayed in orbit for a year and kept sending pictures of Mars back to Earth. The other was destroyed to landing when its parachute failed to deploy. |
| 1981 | Until 1981, all spacecrafts were designed to be used only once. But later, the Space Shuttle was designed to be reused for up to 100 visits to space, which made space travel less expensive. It can fly at a speed of more than 17,000 miles per hour, being equipped with five hugely powerful rocket motors. Six were built, but none of them fly any more – NASA retired the last of the fleet in 2011. |
| 1986 | On 28 January 1986, tragedy struck. Space Shuttle Challenger exploded shortly after launch, since the fuel system failed. All seven astronauts on board were killed, and all shuttles were grounded for nearly three years. This shocking accident reiterated the dangers of space travel, and the incredible bravery of all astronauts. |
| 1986 | The MIR space station was built in sections, with each piece launched by a rocket and then joined together in orbit. In 1986, construction started, with the last piece being fitted ten years later. MIR was the first consistently inhabited long-term space station. It was destroyed in 2001 when it burned up since it crashed back to Earth. |
| 1991 | Helen Sharman, in 1989, become the first British astronaut in space. Helen was the part of a Russian mission to the MIR space station. Helen spent eight days in space, conducting scientific experiments. |

| Year | Achievements |
|---|---|
| 2000 | The first permanent crew moved into the International Space Station (ISS), in 2000. The construction of International Space Station for research and space exploration began in 1986, with the final major module arriving in 2010. |
| 2001 | American millionaire Dennis Tito became the first space tourist in 2001. When he paid around 20 million dollars for a ride in a Russian Soyuz spacecraft. He spent a week in orbit, most of the time visiting the International Space Station. |
| 2004 | The first ever privately funded manned space flight. A new airline, Virgin Galactic has been set up to offer private tourist flights into space, using a new version of this space plane. |
| 2008 | A company, i.e., SpaceX, became the first to launch a privately funded liquid-fuelled rocket into orbit, the Falcon I. |
| 2014 | The world watched as the European Space Agency team successfully oversaw a soft landing by their Philae lander, which conveyed valuable data from the Comet's surface. |
| 2030 | The U.S. National Space Policy of 2010 made some goals for space exploration; to send humans to an asteroid by 2025 and to the planet Mars in the 2030s. |

## INDIAN ASTRONAUTS AND THEIR ACHIEVEMENTS

### 8.13.1 Rakesh Sharma

Rakesh Sharma was the first Indian to travel to space. He was born on 13 January 1949 in Patiala. Rakesh Sharma joined the Indian Air Force (IAF) in 1970; he was a test pilot in IAF and swiftly progressed to other levels. On 20 September 1982, he was selected by the Indian Space and Research Organisation (ISRO) to become a cosmonaut. He went to space as part of a joint mission between ISRO and the Soviet Intercosmos Space Programme, and thus became the first Indian to enter space.

After his return from space, he was given the honour of Hero of Soviet Union. The Indian government awarded him with an Ashoka Chakra.

### 8.13.2 Kalpana Chawla

Kalpana Chawla was the first Indian woman to go into space and also the first Indian–American astronaut. She was born in Karnal, India, in 1962. She had the determination to become an astronaut and that made her pursue many degrees in her field. She held a Ph.D in Aerospace Engineering. Her first flight to space was on Space Shuttle Columbia in 1997 as a mission specialist and primary robotic arm operator.

Unfortunately, in 2003, Kalpana Chawla was part of the Space Shuttle Columbia disaster and lost her life. Kalpana was honoured with the Congressional Space Medal of Honor, NASA Space Flight Medal and NASA Distinguished Service Medal.

### 8.13.3 Sunita Williams

The woman who holds the record for the longest single space flight (195 days) is Sunita Williams. She also holds the record of seven spacewalks, which total up to 50 hours and 40 minutes. She holds the fifth rank when it comes to experienced space walkers.

She was born to Gujarati parents in Euclid, Ohio. On 9 December 2006, Williams was launched into space in STS-116, where she served as the mission specialist.

### 8.13.4 Ravish Malhotra

Ravish Malhotra never went to space; he served as a backup for Rakesh Sharma on Soyuz T-11. Malhotra was born on 25 December 1943. He was awarded with the Kirti Chakra in 1984.

## 8.14 SOME IMPORTANT INTERNATIONAL SPACE MISSION

### 8.14.1 Important Jupiter Missions

**Flyby Missions**

- *Pioneer* programme (1973 and 1974)
- *Voyager* programme (1979)
- *Ulysses* (1992)
- *Cassini* (2000)
- *New Horizons* (2007)

**Orbiter Missions**

- *Galileo* (1995–2003)
- *Juno* (2016)
- *Jupiter Icy Moon Explore* (2023)

### Juno

- **Launch Mass: 3,625 kilograms, Launch date: 5 August 2011, Launch site: Cape Canaveral.**
- It is a space probe **launched by NASA** and **orbiting around the planet Jupiter.**

#### *Objectives of Juno*

- Measurement of the composition, gravity, magnetic field and polar magnetosphere of Jupiter.
- The spacecraft will also search for clues about the formation of the planet, inclusive of having a rocky core, the amount of water it contains within the deep atmosphere, mass distribution and its deep winds reaching the speeds of 618 kilometres per hour. It is the second spacecraft after the nuclear powered Galileo Orbiter (1995–2003) to orbit Jupiter.

#### *Achievements*

- Juno is the **first Jupiter's mission making the usage of solar panels in place of the radio isotope** based thermoelectric generators.

**UNDERSTANDING THE BEGINNING**

We can't understand the origin of the solar system – and how **Earth** came about, without understanding how Jupiter formed.

Scientist community believes that giant planets like Jupiter are the corner stones of planet formation. These planets were assembled early in the process, before their young stars had the chance to absorb or blow away the **light gases** in the huge cloud from which they were born.

Giant planets also play a big role in planet formation because their huge masses allow them to shape the orbits of other objects in their planetary systems, such as other planets, asteroids, and **comets**.

Although we have pieced together the basic story of Jupiter's origin, some important questions remain, and Juno's mission is to help us answer them. Exactly how early was Jupiter born? Jupiter might have formed at its current orbit, but some evidence also suggests that it could have formed farther from the sun before migrating inward. Because Jupiter formed at the same time as the sun, their chemical compositions should be similar. But Jupiter has more heavy elements – such as carbon and **nitrogen** – than the Sun.

Competing formation theories make different predictions about the content and mass of Jupiter's core, so measuring the core will allow us to eliminate ideas that are wrong. Determining the amount of water – and therefore oxygen – in the gas giant is important not only for understanding how the planet formed, but also how heavy elements were transferred across the solar system. These heavy elements were crucial for the existence of rocky planets like Earth – and life.

Since Jupiter is the best example of a gas giant that we have, learning its history will help us understand the hundreds of giant planets we've discovered orbiting other **stars**.

### Jupiter Icy Moon Explorer

ESA's Jupiter Icy Moon Explorer (JUICE) has been selected as part of ESA's Cosmic Vision science programme.

It is launched on 14 April 2023 and after a series of flybys in the inner Solar System arrive in 2031.

In 2012, the European Space Agency's selected the **Jupiter Icy moon Explorer (JUICE)** as its first large mission, replacing its contribution to EJSM (**Europa Jupiter System Mission**), the **Jupiter Ganymede Orbiter** (JGO).

The partnership for the Europa Jupiter System Mission has since ended, but NASA will continue to contribute the European mission with hardware and an instrument.

## 8.14.2 Important Saturn Missions

**How many missions did Saturn have?**

**Four robotic spacecrafts have visited Saturn.** NASA's Pioneer 11 provided the first close look in September 1979. NASA's twin Voyager 1 and Voyager 2 spacecraft followed up with flybys nine months apart in 1980 and 1981.

### CASSINI – HUYGENS (Cassini Orbiter and Huygens: Lander)

**[Launch mass: 5,712 kilograms, Launch date: 15 October 1997, Launch site: Cape Canaveral]**

**Cassini – Huygens** is an **unmanned spacecraft sent to the planet Saturn.**

It is the **fourth space probe to visit Saturn** and the **first to enter orbit.**

- Team: **Sixteen European countries and the US** are responsible for designing, building, flying and collecting data from Cassini Orbiter.
- It completely **destroyed on 15 September 2017.**

### *Achievements*

- The first mission to successfully complete in various observations: depth, up-close study of Saturn and its realm from orbit.
  Titan was revealed to have Earth like conditions: rain, rivers, lakes and sea.
- Among the most surprising discoveries were geysers erupting on Enceladus.
  First complete view of the North polar hexagon and discovery of giant hurricanes at both of the Saturn's poles.

## Titan

**[Proposed launch date: between 2020 and 2029, Launch mass: 1613 kilograms]**

**Titan Saturn System Mission (TSSM)** was a joint **NASA–ESA** proposal for an exploration of Saturn and its moons **Titan** and **Enceladus**, where many complex phenomena were revealed by *Cassini*. TSSM was launched in 2020, get **gravity assists** from Earth and Venus, and arrive at the Saturn system in 2029. The 4-year prime mission would include a two-year Saturn tour, a 2-month Titan aero-sampling phase, and a 20-month Titan orbit phase. NASA **has delayed** the launch of a **mission** to **Saturn's** moon **Titan** by a year, citing budget challenges created by the corona virus pandemic.

This is a Saturn exploration mission proposed for the future. The mission has been proposed to study Saturn and its Moons – **Titan and Enceladus.**

The Titan Saturn System Mission (TSSM) was officially decided in January 2009 by the **merging of ESA's Titan and Enceladus Mission with NASA's Titan Explorer study.**

**The TSSM mission consists of an orbiter and two titan exploration probes: a 'hot air balloon' that will float in Titan's clouds** and a **'lander' that will splash down on one of its methane seas.**

### *Objectives of TSSM*

- It will try to identify the reason behind Titan's origin and its evolution models.
- **Recover information on Enceladus and Saturn's magnetosphere.**

## NASA to Launch Dragonfly

NASA plans to launch an unmanned nuclear-powered drone, Dragonfly as early as 2027 and arrive in 2034 to search for life on Saturn's largest moon, Titan.

The rotorcraft will fly to dozens of promising locations on Titan looking for prebiotic chemical processes common on both Titan and Earth. For the first time NASA will use multi-rotor vehicle on another planet; it contains eight rotors and flies like a large drone. It will take advantage of Titan's dense atmosphere which are four times denser than Earth.

**Titan is an analog to the very early Earth, and can provide clues to how life may have arisen on our planet.**

During its 2.7 year journey, Dragonfly will try to explore diverse environments from organic dunes to the floor of an impact crater where liquid water and complex organic materials key to life once existed. Its instruments will study how far prebiotic chemistry may have progressed. They also will investigate the moon's atmospheric and surface properties and its subsurface ocean and liquid reservoirs. Additionally, instruments will search for chemical evidence of past or extant life.

**Titan has a nitrogen-based atmosphere similar to Earth.** Unlike Earth, Titan has clouds and rain of methane. Other organics are formed in the atmosphere and fall like light snow. **The moon's weather and surface processes have combined complex organics, energy and water similar to those that may have sparked life on our planet.**

**Titan is larger than the planet Mercury and is the second largest moon in our solar system.** As it orbits Saturn, it is about 1.4 billion kilometres away from the Sun, about 10 times farther than Earth. Because it is so far from the Sun, its surface temperature is around –290 degrees Fahrenheit (–179 degrees Celsius). Its surface pressure is also 50% higher than Earth's.

## 8.14.3 Important Mars Missions

There have been around 50 Mars missions so far, of which about half have been successful.

Mariner 9 was the first spacecraft that successfully entered into Mars orbit on 1971.

Some important Mars Missions are:

- **Mars Odyssey** (2001)
- **Mars Express** (2003)
- **Mars Spirit and Opportunity** (2003)
- **Mars Reconnaissance Orbiter** (2005)
- **Curiosity Rover** (2011)
- **Mangalyaan (Mars Orbiter Mission)** 2013
- **MAVEN** (2013)
- **ExoMars Trace Gas Orbiter** (2016)
- **InSight Lander** (2018)
- **Hope Mars Mission** (2020)
- **Perseverance Rover** (2020)
- **Tianwen-1** (2020)

### Mars Science Laboratory (MSL)

**[Launch mass: 3.839 kilograms, Launch date: 26 November 2011, Launch site: Cape Canaveral]**

MSL is a **robotic space probe mission to Mars** launched by **NASA**, which **successfully landed 'Curiosity,' a Mars rover, in Gale Crater** on 6 August 2012.

'Curiosity' is about **twice as long and five times as heavy as the previous Mars rovers 'Spirit' and 'Opportunity'** and carries over ten times the mass of scientific instruments.

#### *Scientific Goals of MSL*

1. **Determining the landing sites and its habitability**, including the **role of water**.
2. The **study of the climate and the geology of Mars**.
3. All of these are **important for preparing a future manned mission to mars.**

#### *Objectives*

- Study of organic carbon compounds, building blocks of life, identify biosignature.
- Investigate chemical and mineralogy of Martian surface.
- Assess Maritan atmosphere, determine present state, distribution and cycling of water and $CO_2$.
- Characterise the surface radiation.

### Curiosity Rover

**[Launch mass: Rover only of 899 kilograms, Launch date: 26 November 2011]**

Curiosity is a **car-sized robotic rover exploring Gale Cater on Mars** as a **part of NASA's Mars Science Laboratory mission.**

Since landing on 6 August 2012, it is still working.

In December 2012, Curiosity's mission was extended to an indefinite period. **The goals and objectives remain same as those of Mars Science Laboratory.**

### Maven Spacecraft

The MAVEN mission was **launched on November 18, 2013**, and **went into orbit around Mars on September 21, 2014.**

**Mars Atmosphere and Volatile Evolution (MAVEN)** mission was **devised by NASA** for studying the Martian atmosphere during the Mars orbiting.

MAVEN was **launched aboard through an Atlas V launch vehicle.**

Mars Atmosphere and Volatile Evolution (MAVEN) finished its chief mission in the November 2015 and since that time, has been **functioning in an extended mission**, continuing the Mars' upper atmosphere investigation and exploring further opportunities for science that the new relay orbit will bring. **It also discovered two new types of Martian auroras – diffuse aurora and proton aurora.**

MAVEN has **demonstrated** that the **majority of the carbon dioxide ($CO_2$) on the planet has been lost to space.**

### ExoMars Programme

It is a **joint endeavour** between **ESA and the Russian space agency, Roscosmos**. The primary goal of the ExoMars programme is to address the question of **whether life has ever existed on Mars.**

**The programme comprises two missions.**

- The **first** launched in March 2016 and consists of the **Trace Gas Orbiter (TGO) and Schiaparelli**, an entry, descent and landing demonstrator module. **TGO's main objectives are to search for evidence of methane and other trace atmospheric gases that could be signatures of active biological or geological processes.** The **Schiaparelli probe crashed during its attempt to land on Mars.**
- The **second, comprising a rover (ExoMars Rover) and surface platform, is planned for 2022.** Together they **will address the question of whether life has ever existed on Mars.**

### InSight Lander

Launched in May 2018, with a successful landing in November 2018 of same year, the InSight Lander, short for '**Interior Exploration using Seismic Investigations, Geodesy and Heat Transport**' aims to **study the core of Mars and observe any possible seismic activity on the planet's surface**.

- InSight is part of **NASA's Discovery Program.**
- It will be **the first mission to peer deep beneath the Martian surface,** studying the planet's interior by measuring its heat output and listening for marsquakes, which are seismic events similar to earthquakes on Earth.
- It will **use the seismic waves generated by marsquakes to develop a map of the planet's deep interior.**

#### *New Results:*

- NASA's InSight lander has recorded over 500 quakes to date on Mars since its touch down on the Red Planet in November 2018.
  These findings support the idea that the planet is seismic ally active.

#### *Significance of the Mission:*

- The findings of Mars' formation will help better understand how other rocky planets, including Earth, were and are created.
- InSight would delve deep beneath the surface of Mars, detecting the fingerprints of the processes of terrestrial planet formation, as well as measuring the planet's "vital signs": its "pulse" (seismology), "temperature" (heat flow probe), and "reflexes" (precision tracking).
- InSight seeks to answer one of science's most fundamental questions: **How did the terrestrial planets form?**

### HOPE Mission

**HOPE Mission** – the **first Arab interplanetary mission** – was announced in 2015 with the aim of creating mankind's first integrated model of the Red planet's (Mars) atmosphere. 'Hope' was developed by UAE scientists in the USA and was launched in **July 2020** from the Tanegashima Space Centre in Japan.

The Hope mission is **a Mars orbiter spacecraft,** which will study the thin atmosphere of Mars. The mission is officially named **the Emirates Mars Mission (EMM) and the orbiter has been named Hope or 'AlAmal'.** It is the first interplanetary mission for the Arab World.

#### *The Hope Orbiter*

- The Mars Hope Probe **weights just 1.5 tonnes.** It is **expected to complete one orbit around the planet every 55 hours.**
- The **overall life of UAE's Mars mission is around one Martian year,** which is about 687 days on Earth.

**The three main objectives of the Hope probe are:**

1. To understand the climate dynamics and global weather map of Mars by studying the lower atmosphere of Mars.
2. To explain how the weather of Mars affects the escape of hydrogen and oxygen, by correlating conditions in the lower and upper atmosphere.
3. To understand the presence and variability of hydrogen and oxygen in the upper atmosphere, and why Mars is losing these gases to space.

#### *Significance of the Mission:*

1. It is a known fact that the Red Planet was once habitable, from signatures of flowing water and organic material that point to a past that could have supported living things.
2. An understanding of Mars past could help scientists understand the future of Earth.

Note: With the successful Mars orbit insertion, the **UAE becomes the fifth entity to reach the Red Planet, joining NASA,** the Soviet Union, the European Space Agency and India.

### NASA's Perseverance's Mission on Mars

**It was** launched on **July of 2020** from Cape Canaveral Air Force Station in Florida. This was **the third constitutive launch to Mars on July 2020, following the UAE's Hope** and China's Tianwen-**1 spacecraft.**

#### *Key Facts*

1. **Landing date – 18 February 2021**
2. The mission is planned to last for at least **one Mars year, which works out to about 687 days on Earth** (it takes longer for Mars to go around the sun).
3. **Landing site:** Jezero crater.
4. **Perseverance is loaded with seven instruments** chosen to help it achieve its mission objectives.

### *Some of the Key Mission Objectives*

1. Look for signs of ancient microbial life.
2. Collect Martian rock and dust samples for later return to Earth.
3. Deliver an experimental helicopter.
4. Study the climate and geology of Mars.
5. Demonstrate technology for future Mars missions.

### *Significance of This Mission*

1. Perseverance will carry **a unique instrument, MOXIE or Mars Oxygen ISRU Experiment:** which for the first time will **manufacture molecular oxygen on Mars using carbon dioxide from the carbon-dioxide-rich atmosphere** (ISRU means In Situ Resource Utilisation: or the use of local resources to meet human needs or requirements of the spacecraft).
2. It will carry **Ingenuity, the first ever helicopter to fly on Mars.** This is the first time NASA will fly a helicopter on another planet or satellite.
3. It is **the planned first step to bring back rock samples from Mars for analysis in sophisticated laboratories on Earth** and do its **biosignatures** (try to detect past or present life).

### *(A) NASA Mars Helicopter "Ingenuity" Makes First Flight on Another Planet*

- NASA's **Ingenuity mini-helicopter** has been dropped on the surface of Mars in preparation for its first flight.
- The helicopter had been fixed to the belly of **the Perseverance rover,** which touched down on the Red Planet on 18 February 2020.
- NASA successfully flew its tiny helicopter **Ingenuity** on Mars on 19th April 2020, **the first powered flight on another planet.**
- Ingenuity's goal is to demonstrate its technology works, and it won't **contribute to Perseverance's science goals.**

### Challenges on Martian Surface for Ingenuity

- Ingenuity will be attempting to fly in an atmosphere that is one per cent the density of Earth's, which makes achieving lift harder – but will be assisted by gravity that is one-third of our planet's.
- It will have to use its own battery to run a vital heater to protect its unshielded electrical components from freezing and cracking during the bitter Martian night.

### About Ingenuity Mars Helicopter

- Part of NASA's Mars 2020 mission, the small coaxial, drone rotorcraft will serve as a technology demonstrator for the potential use of flying probes on other worlds, with the potential to scout locations of interest and support the future planning of driving routes for Mars rovers.

### *(B) Perseverance Mission has Extracted Oxygen on Mars*

- A device aboard the rover was able to produce oxygen from the thin Martian atmosphere for the first time.
- It promises hope for future crewed missions that can rely on this technology for astronauts to breathe and return to Earth.

### Composition of Martian Atmosphere

- On Mars, carbon dioxide makes up ~96% of the gas in the planet's atmosphere. Oxygen is only 0.13%, compared to 21% in Earth's atmosphere.

### *How did Perseverance Produce Oxygen on Mars?*

- The **Mars Oxygen In-Situ Resource Utilisation Experiment (MOXIE)** produced 5 grams of **oxygen from carbon dioxide** in the Martian atmosphere, enough for an astronaut to breathe for 10 minutes.
- Like a tree on Earth, MOXIE inhales carbon dioxide and exhales oxygen.
- To produce oxygen, MOXIE separates oxygen atoms from carbon dioxide molecules. It does so by using heat at a temperature of around 800 degrees Celsius.
- In the process, it also produces carbon monoxide as a waste product, which it releases in the Martian atmosphere.

### *About MOXIE*

- A technology demonstrator, MOXIE is designed to generate up to 10 grams of oxygen per hour, and is placed inside the Perseverance rover.
- It is the size of a car battery, weighing 37.7 pounds (17.1 kg) on Earth, but just 14.14 pounds (6.41 kg) on Mars.
- Over the next two years, MOXIE is expected to extract oxygen nine more times.

**Why is producing oxygen on the Red Planet so important?**

- Oxygen supply on Mars is essential for crewed missions to Mars – not just for astronauts to breathe but for rockets to use as fuel while coming back to Earth.
- As per NASA, for four astronauts to take off from Mars, a future mission would require around 7 metric tons of rocket fuel and 25 metric tons of oxygen–around the weight of an entire space shuttle.
- In contrast, **astronauts living and working on Mars would require far less oxygen to breathe**, maybe around one metric ton.
- Thus, it will be an enormous challenge to haul the 25 metric tons of oxygen from Earth to Mars for the return journey, and that their job would become significantly easier if the liquefied oxygen can be produced on the Red Planet.

### *What is the Reason for the Near-Term Interest in Mars?*

Mars is located in the very near backyard (about 200 million km away).

It is a planet that humans can aspire to visit or to stay for a longer duration.

- Mars had flowing water and an atmosphere in the distant past: and perhaps conditions to support life.

In the near term, the increase in interest related to Mars is because of **Elon Musk's plans for commercial travel.**

### China's Tianwen-1 Probe

The mission was launched from the Wenchang Spacecraft Launch Site on 23 July 2020. China's Tianwen-1 probe has successfully entered orbit around Mars on 10 February 2021, after a 6-1/2- month journey from Earth.

In about three months, the Tianwen-1 will attempt to send a landing capsule carrying a 240-kilogram rover in a rapid seven-minute descent onto a massive plain in the northern hemisphere of Mars known as Utopia Planitia.

### *About Tianwen-1*

- China's first Mars probe is called Tianwen-1 (formerly Huoxing-1).
- The space craft consists of an orbiter, a lander and a rover.
- Launched last year on a Long March 5 rocket from Xichang, China.
- **Landing site:** Somewhere in Utopia Planitia, a vast plain in Mar's northern latitudes and the same place NASA's Viking 2 mission landed in the 1970s.
- If the mission is successful, China will become the third country to achieve a Mars landing after the USSR and the United States.

There are five core science objectives:

1. Create a geological map of Mars.
2. Explore the characteristics of the Martians oil and potentially locate water-ice deposits.
3. Analyse the surface material composition.
4. Investigate the Martian atmosphere and climate at the surface.
5. Understand the electromagnetic and gravitational fields of the planet.

### *Zhurong (China's first Mars rover)*

**China's first Mars rover** will be named Zhurong after a traditional fire god. The rover is aboard the Tianwen-1 probe that arrived in Mars orbit on February 24, 2021 and is due to land in May to look for evidence of life.

### *Significance of the Mission*

- **China in 2019 became the first country to land a space probe on the little-explored far side of the moon** and in December returned lunar rocks to Earth for the first time since the 1970s.
- China would become **the third country after the former Soviet Union and the United States to put a robot rover on Mars.**

## 8.14.4 Important Mercury Missions

Only 2 spacecraft have ever visited Mercury as of 2023, and a third is on the way. It actually takes more energy for a spacecraft to reach Mercury than Pluto. Mercury is the fastest-orbiting planet in our solar system – it blazes around the Sun at 48 kilometres per second.

- **Mariner 10** (1973)
- **Messenger** (2004)
- **BepiColombo** (2018)

### Messenger Mission

MESSENGER was a **NASA robotic spacecraft that orbited the planet Mercury between 2011 and 2015.** The spacecraft was **launched aboard a Delta II rocket in August 2004** to study Mercury's chemical composition, geology, and magnetic field. MESSENGER **entered**

**orbit around Mercury on 18 March 2011**, becoming the first spacecraft to do so.

The MESSENGER mission was planned to study **Mercury's features and environment** from orbit.

Particularly, the mission's scientific objectives were:

- Characterising the planet surface's chemical composition.
- Studying the geologic history of planet.
- Elucidating the global magnetic field nature (magnetosphere).
- Determining the core's size and state.
- Determining the poles' volatile inventory.
- Studying the planet's exosphere nature.

### BepiColombo

- BepiColombo is a joint **European-Japanese mission** to explore the planet Mercury. **It launched in 2018 and will enter Mercury orbit in 2025.**
- The mission will **study water ice at Mercury's poles and the planet's abnormally large core.** This will ultimately help us learn how Mercury formed, and what the early solar system was like.
- Mercury is a mysterious, contradictory world. **Despite being the closest planet to the Sun with surface temperatures of 430 degrees Celsius (800 degrees Fahrenheit), Mercury has water ice hidden in shadowed craters near its poles.**
- The planet's surface appears old and cratered, undisturbed by geologic activity like volcanoes. Yet it has a magnetic field, which is normally caused by a molten core that should, in turn, cause surface changes.
- These apparent contradictions make Mercury as intriguing as any other planet in our solar system, yet only two missions (NASA's Mariner 10 and MESSENGER) have ever studied it up close. MESSENGER discovered Mercury's core makes up 85% of the planet's volume, much more than Earth's, which is just 15%.

**NOMENCLATURE**

BepiColombo is named in honour of Giuseppe "Bepi" Colombo (1920–1984), an Italian mathematician-engineer who explained Mercury rotating 3 times for every 2 orbits around the Sun.

## 8.14.5 Important Solar Missions

**I[st] Phase: (1960–1969)**
- Pioneer 5 (1960)
- Pioneer 6 (A) (1960)
- Pioneer 7 (B) (1960)
- Pioneer 8 (C) (1960)
- Pioneer 9 (D) (1960)
- Pioneer E (1960)

**II[nd] Phase: (1974–1997)**
- Helios A (1974)
- Helios B (1976)
- ISEE-3 (1978)
- ULYSSES (1994)
- WIND (1994)
- SOHO (1996)
- ACE (1997)

**III[rd] Phase: (2000 – Present)**
- ULYSSES (2000)
- Genesis (2001)
- STEREO A (2006)
- STEREO B (2006)
- Ulysses (2007)
- DSCOVR (2015)
- Parker Solar Probe (2018–2025)
- Solar Orbiter (10 Feb, 2020 Launched)

### Parker Solar Probe

**NASA's historic Parker solar probe launched on 12 August 2018 from the Cape Canaveral.**

It is a **small car sized spacecraft, which will travel at a distance of 4 millions miles from the Earth surface.** It will be **first ever mission to touch the Sun.**

#### *About the Mission*

Parker Solar Probe will travel closer to the Sun's surface than any other spacecraft had done before, through the **Sun's atmosphere, facing vicious conditions of heat and radiation and eventually providing humankind with the closest-ever star observations.**

The corona is hotter than the Sun's surface and also give rise to the solar wind which being charged particles has a continuous flow that infuses the solar system.

Capricious solar winds cause turbulence in Earth's magnetic field and can play havoc with Earth's communications technology.

NASA anticipates the results will facilitate scientists for forecasting changes in Earth's space environment.

*Parker Solar Probe*

**On 12 August 2019, NASA's Parker Solar Probe completed a year in service.**

It is **part of NASA's "Living With a Star" programme** that explores different aspects of the Sun-Earth system. The probe seeks to gather information about the Sun's atmosphere and NASA says that it **"will revolutionise our understanding of the Sun"**. It is also the closest a human-made object has ever gone to the Sun.

**Solar Orbiter/SOLO Mission**

Solar Orbiter is a space mission of **international collaboration between ESA (European Space Agency) and NASA.**

- The spacecraft was launched from **Cape Canaveral on a United Launch Alliance Atlas V rocket** in **February 2020.**
  It was selected as **the first medium-class mission of ESA's Cosmic Vision 2015–2025 Programme.**
  This is **the first mission that will provide images of the sun's north and south poles.**
  It is **a seven-year mission** and will **come within 26 million miles of the sun.**
  It will be able to brave the heat of the sun because it has a custom **titanium heat shield coated in calcium phosphate** so that it **can endure temperatures up to 970 degrees Fahrenheit.**

**The European Space Agency** has released the closest pictures ever taken of the Sun captured by **the Solar Orbiter** that was **launched on 10 February 2020**. The spacecraft completed its **first close pass of the Sun** in mid-June, when it **flew within 48 million miles of the Sun** with 10 instruments turned on to snap the closest pictures of the giant star to date.

***Observations Made from These Images:***

1. There are **miniflares on the sun** that the scientists are calling **"camp fires".**
2. Size: These **campfires** are **millionths of the size of the Sun's massive flares** that are routinely observed by Earth telescopes.
3. These **small flares could have something to do with the heating process that makes the corona, the Sun's outer atmosphere, far hotter than its surface.**

**Solar Flares**

- It is **a large explosion of magnetic energy in the Sun's atmosphere** which causes an intense burst of increased brightness.
- Flares occur in active regions around **sunspots.**
- **During solar flares,** the Sun releases bursts of **energetic particles that enhance the solar wind** that constantly emanates from the star into the surrounding space.
- When these energetic particles interact with Earth's magnetosphere, they can cause **magnetic storms that can disrupt telecommunication networks and power grids on the ground.**

**Corona**

- The solar corona is **the outermost layer of the Sun's atmosphere** that extends millions of kilometres into outer space.
- After many decades of studies, **the physical mechanisms that heat the corona are still not fully understood,** but identifying them is considered the 'holy grail' of solar physics.

**PUNCH Mission**

**(Polarimeter to Unify the Corona and Heliosphere) NASA has selected Texas-based Southwest Research Institute to lead** its **PUNCH mission which will image the Sun.**

This is a landmark mission that will image regions beyond the Sun's outer corona.

**Dipankar Banerjee**, solar physicist from **Indian Institute of Astrophysics is also a Co-Investigator** of the PUNCH mission.

**It is focussed on understanding the transition of particles from the Sun's outer corona to the solar wind that fills interplanetary space.** It will consist of a constellation of four microsatellites that, through continuous 3D deep-field imaging, will observe the corona and heliosphere as elements of a single, connected system. **The mission is expected to be launched in 2025.**

## 8.14.6 Solar System and Beyond

**In Progress**

- NASA's **Hubble Space Telescope** is a multipurpose astrophysics and planetary science observatory.
- ESA's **CHEOPS** precisely measures the diameters of known exoplanets.
- NASA's **TESS** hunts for exoplanets around a specific type of bright stars.

- NASA's **James Webb Space Telescope was launched on** December 25, 2021 from **ESA's launch site at Kourou in French Guiana.**

**Coming Soon**

- NASA's **Roman Space Telescope** will launch in 2025 and image Earth-sized exoplanets.

### Hubble Space Telescope

Hubble Space Telescope is a large, space-based observatory, which has revolutionised astronomy since its launch and deployment by the space shuttle Discovery in 1990. Far above rain clouds, light pollution, and atmospheric distortions, Hubble has a crystal-clear view of the universe.

Scientists have used Hubble to observe some of the most distant stars and galaxies yet seen, as well as the planets in our solar system. Hubble's capabilities have grown immensely in its over 30 years of operation.

Telescopes have a particular range of light that they can detect. Hubble's domain extends from the ultraviolet through the visible (which our eyes see) and into the near-infrared. This range has allowed Hubble to deliver stunning images of stars, galaxies, and other astronomical objects that have inspired people around the world and changed our understanding of the universe.

**Hubble has made more than 1.4 million observations over the course of its lifetime.** Over 18,000 peer-reviewed science papers have been published on its discoveries, and every current astronomy textbook includes contributions from the observatory.

The telescope has tracked interstellar objects as they soared through our solar system, watched a comet collide with Jupiter, and discovered moons around Pluto. It has found dusty disks and stellar nurseries throughout the Milky Way that may one day become full-fledged planetary systems and studied the atmospheres of planets that orbit other stars.

Hubble has peered back into our universe's distant past, to locations more than 13.4 billion light years from Earth, capturing galaxies merging, probing the super massive black holes that lurk in their depths, and helping us better understand the history of the expanding universe.

In its over 30 years of operation, Hubble has made observations that have captured humanity's imaginations and deepened our knowledge of the cosmos. It will also continue in coming years.

### Cheops

Cheops is ESA's **Characterising Exoplanet Satellite.** It is the first mission dedicated to studying bright, nearby stars that are already known to host exoplanets, in order to make high-precision observations of the planet's size as it passes in front of its host star.

It will focus on planets in the super-Earth to Neptune size range, with its data enabling the bulk density of the planets to be derived, a first-step characterisation towards understanding these alien worlds.

**LAUNCH**

**Launch date:** 18 December 2019
**Launch site:** Kourou, French Guiana
**Launcher:** Soyuz-Fregat
**Orbit:** Sun-synchronous, dusk-dawn orbit at 700 km above Earth

### Transiting Exoplanet Survey Satellite (TESS)

The Transiting Exoplanet Survey Satellite (TESS) is a NASA mission that will look for planets orbiting the brightest stars in Earth's sky. It was led by the Massachusetts Institute of Technology with seed funding from Google.

The mission will monitor at least 200,000 stars for signs of exoplanets, ranging from Earth-sized rocky worlds to huge gas giant planets. **TESS will focus on stars that are 30 to 100 times brighter than those Kepler examined.** This will help astronomers better understand the structure of solar systems outside of our Earth, and provide insights into how our own solar system formed.

TESS will occupy a never-before-used orbit high above Earth. The elliptical orbit, called P/2, is exactly half of the moon's orbital period, this means that TESS will orbit Earth every 13.7 days.

It will use transit method to detect exoplanets. It watches distant stars for small dips in brightness, which can indicate that planet has passed in front of them. Repeated dips will indicate planet passing in front of its star. This data has to be validated by repeated observations and verified by scientists.

**KEPLER MISSION**

**Launched in the year 2009, for surveying the Milky Way galaxy region so as to discover hundreds of Earth-size and smaller planets in or around the habitable zone** and determining in our galaxy, the fraction of the hundreds of billions of stars that might have such planets.

As on March 2018, 2,342 planets had been found confirmed by the Kepler; added potential planets, and its finding of exo-worlds stands at 4,587.

Scientists have discovered a cache over 100 new exoplanets using data from NASA's Kepler Space telescope as well as ground-based observatories. The diverse planets are expected to play a large role in developing the research field of exoplanets and life in the Universe.

The Kepler Space Telescope has been officially retired by NASA. Its successor space telescope, called TESS (The Transiting Exoplanet Survey Satellite), has already started collecting data.

### James Webb Space Telescope

The James Webb Space Telescope (also called JWST or Webb) will be a **large infrared telescope** with a 6.5-meter metre primary mirror. The telescope was launched on December 25, 2021 from **ESA's launch site at Kourou in French Guiana.**

- JWST is **a joint venture between the US (NASA), European (ESA) and Canadian space agencies (CSA).**
- It is an orbiting infrared observatory that will complement and extend the discoveries of **the Hubble Space Telescope** with longer wavelength coverage and greatly improved sensitivity.
- Webb was formerly known as **the "Next Generation Space Telescope" (NGST)** and it was renamed in 2002 after a former NASA administrator, James Webb.
- It will be a large infrared telescope with an approximately 6.5 meter primary mirror.

#### *Objectives and Functions of the Telescope*

1. It will look deeper into the cosmos and thus further back in time than is possible with Hubble.
2. It will do this with a much bigger mirror (6.5 meter in diameter versus 2.4 meter) and instruments that are tuned to the infrared.
3. Scientists hope this set-up can detect the light from the very first population of stars in the Universe to switch on more than 13.5 billion years ago.

#### *Orbit*

- **The Hubble Space Telescope** orbits around the Earth at an altitude of approximately 570 km.
- Webb will not actually orbit the Earth, instead it will sit at **the Earth-Sun L2 Lagrange point**, 1.5 million km away.
- At **the L2 point Webb's solar shield** will block the light from the Sun, Earth, and Moon which will help Webb stay cool, which is very important for an infrared telescope.

(Refer **Infographic – James Webb Telescope vs Hubble Space Telescope**)

### Roman Space Telescope/Wide-Field Infrared Survey Telescope (WFIRST)

On 17 February 2016, WFIRST was approved for development and launch but now it is renamed as Roman Space Telescope. The Roman Space Telescope is a NASA observatory designed to unravel the secrets of dark energy and dark matter, search for and image exoplanets, and explore many topics in infrared astrophysics. The Roman Space Telescope will have two instruments, the Wide Field Instrument, and the Coronagraph Instrument.

- The Roman Space Telescope has a 2.4 m telescope, the same size as Hubble's, but with a view 100 times greater than Hubble's.
- The Roman Space Telescope was the top-ranked large space mission in the 2010 Decadal Survey of Astronomy and Astrophysics.
- The Roman Space Telescope is slated to launch in the mid-2020s.
- The Roman Space Telescope will have no proprietary data period and all observing time will be competed.

The Wide Field Instrument will have a field of view that is 100 times greater than the Hubble infrared instrument, capturing more of the sky with less observing time. As the primary instrument, the Wide Field Instrument will measure light from a billion galaxies over the course of the mission lifetime. It will perform a microlensing survey of the inner Milky Way to find approx 2,600 exoplanets. The Coronagraph Instrument will perform high contrast imaging

- 1 million miles (1.5 million km) from Earth
- Orbiting the Sun at Sun-Earth Lagrange Point 2 (L2)

**ORBIT**

**SCIENCE TARGETS**

- First light & reionization
- Earliest galaxies in the universe
- How galaxies evolve
- Birth of stars and planets
- Exoplanets

**STATUS**

Webb successfully launched from ESA's spaceport in French Guiana on December 25, 2021 @ 07:20 AM EST

**NAMED FOR**

## James E. Webb

- The James Webb Space Telescope (JWST or Webb) is a large infrared telescope with a 6.5-meter primary mirror, launched on December 25, 2021 from French Guiana.
- The JWST (James Webb Space Telescope) is a collaborative effort between NASA (US), ESA (European Space Agency), and CSA (Canadian Space Agency).
- The JWST is an orbiting infrared observatory that will enhance and expand upon the achievements of the Hubble Space Telescope. It will provide coverage of longer wavelengths and significantly improved sensitivity.
- The James Webb Space Telescope (JWST) was originally referred to as the "Next Generation Space Telescope" (NGST) and later renamed in 2002 in honor of James Webb, a former NASA administrator.
- The James Webb Space Telescope (JWST) will boast a substantial infrared telescope with an approximate primary mirror size of 6.5 meters.
- Objectives and functions of the telescope:
  a. The JWST will explore deeper into the cosmos, revealing a glimpse further back in time than Hubble.
  b. With its significantly larger 6.5-meter diameter mirror and infrared-tuned instruments, the JWST will accomplish this task more effectively than the Hubble telescope.
  c. Scientists anticipate that the JWST's setup will detect light from the universe's first stars, which ignited over 13.5 billion years ago.
- Orbit:
  a. The Hubble Space Telescope orbits around the Earth at an altitude of approximately 570 km.
  b. Webb will not actually orbit the Earth, instead it will sit at the Earth-Sun L2 Lagrange point, 1.5 million km away.
  c. At the L2 point Webb's solar shield will block the light from the Sun, Earth, and Moon which will help Webb stay cool, which is very important for an infrared telescope.

- 340 miles (545 km) above Earth
- Orbiting Earth

**ORBIT**

**SCIENCE TARGETS**

- Structure of the universe
- Dark energy
- How galaxies evolve
- Exoplanets

**STATUS**

Operating in space since 1990

**NAMED FOR**

## Edwin P. Hubble

- The Hubble Space Telescope, launched in 1990, is a space-based observatory that revolutionized astronomy by providing a clear view of the universe above Earth's atmosphere.
- Over its 30 years of operation, scientists have utilized the Hubble Space Telescope to observe distant stars, galaxies, and even planets within our solar system, witnessing remarkable advancements in its capabilities.
- Telescopes are limited to detecting a specific range of light, but the Hubble Space Telescope has an extended domain that covers ultraviolet, visible, and near-infrared wavelengths. This broad range has enabled Hubble to capture breathtaking images of stars, galaxies, and celestial objects, captivating people worldwide and revolutionizing our knowledge of the universe.
- Hubble has made over 1.4 million observations, resulting in 18,000+ published papers and contributions to every astronomy textbook.
- Hubble has observed interstellar objects, witnessed a comet colliding with Jupiter, discovered moons around Pluto, detected stellar nurseries, and studied exoplanet atmospheres.
- Hubble has observed galaxies merging, studied supermassive black holes, and provided insights into the expanding universe's history, reaching over 13.4 billion light years away.
- Throughout its 30+ years of operation, Hubble has made captivating observations that have sparked our imagination and expanded our understanding of the universe. Furthermore, Hubble is set to continue its mission in the years to come.

and spectroscopy of dozens of individual nearby exoplanets.

The Roman Space Telescope will have a primary mission lifetime of 5 years, with a potential 5 year extended mission.

### Chandra X-ray Observatory

Chandra X-ray Observatory was launched on **23 July 1999** as NASA's flagship mission for X-ray astronomy, taking its place in the fleet of "Great Observatories".

This telescope is specially designed to detect X-ray emission from very hot regions of the Universe such as exploded stars, clusters of galaxies, and matter around black holes. Because X-rays are absorbed by Earth's atmosphere, Chandra must orbit above it, up to an altitude of 139,000 km (86,500 mi) in space.

The **Smithsonian's Astrophysical Observatory** in Cambridge, hosts the Chandra X-ray Centre which operates the satellite, processes the data, and distributes it to scientists around the world for analysis. Chandra carries four very sensitive mirrors nested inside each other.

Chandra has imaged the spectacular, glowing remains of exploded stars, and taken spectra showing the dispersal of elements. **Chandra has observed the region around the super massive black hole in the centre of our Milky Way, and found black holes across the Universe.** It has traced the separation of dark matter from normal matter in the collision of galaxies in a cluster and is contributing to both dark matter and dark energy studies. As its mission continues, Chandra will continue to discover startling new science about our high-energy Universe in future.

### Thirty Meter Telescope (TMT)

TMT is a planned ground-based mirror reflecting telescope that is backed by giant R&D spending countries, namely China, Japan, Canada, USA and India. Mauna Kea, Hawaii, was proposed as a feasible site for the large telescope.

It is planned to observe from near UV to mid-infrared wavelengths, and in addition, it corrects for the blurs caused by the atmosphere by its intuitive and adaptive optics system. It is supposed to be, the highest and will be the second largest telescope after the E-ELT (European Extremely Large Telescope), which uses an array of small 1.44-metre hexagonal mirrors. The design is far different from large mirror of Large Binocular Telescope (LBT) and Giant Magellan Telescope (GMT).

#### *Set to Begin Construction*

The mega telescope completed its design and development phase in 2009, but legal challenges from Native Hawaiian activists, who treasure Mauna Kea for cultural and religious reasons have hounded the telescope.

#### *About TMT*

- The Thirty Meter Telescope (TMT) is a proposed **astronomical observatory with an extremely large telescope (ELT).**
- It is an **international project** being funded by scientific organisations of ***Canada, China, India, Japan and USA.***
- **Planned location:** ***Mauna Kea on the island of Hawaii*** in the US state of Hawaii.
- The TMT is designed for **near-ultraviolet to mid-infrared observations.**

#### *Potential*

- TMT will enable scientists **to study fainter objects far away from us** in the Universe, which gives information about early stages of evolution of the Universe.
- It will give us **finer details of not-so-far-away objects like undiscovered planets and other objects in the Solar System** and planets around other stars.

Indian astronomers collaborated with Nobel laureate on Thirty Meter Telescope Project. **2020 Physics Nobel Laureate Prof. Andrea Ghez** had worked closely with Indian astronomers on the design of back-end instruments.

### Growth India Telescope (GIT)

The GROWTH-India telescope is part of a multi-country joint initiative, termed as the **Global Relay of Observatories Watching Transients Happen (GROWTH),** for observance of universe's transient events.

- The **fully robotic telescope** is intended to confine cosmic events happening over relatively small periods of the cosmological timescale: years, days and even hours.
- **The US, UK, India, Japan, Germany, Taiwan and Israel Universities and research institutes are part of the initiative.**

- **Their key research goal is time-domain astronomy, which brings about the study of explosive transients and changeable sources (of light and other radiation) in the universe.**
- **The 0.7 m GROWTH-India telescope at the Indian Astronomical Observatory located in Hanle, Ladakh, has made its first science observation which is a follow-up study of a nova explosion. Novae are explosive events involving violent eruptions on the surface of white dwarf stars, leading to temporary increase in brightness of the star.**

### Square Kilometre Array

On 4th Feb 2021, **the Square Kilometre Array Observatory (SKAO) Council** held its maiden meeting and approved the establishment of **the world's largest radio telescope.**

#### *About SKAO*

SKAO is a new intergovernmental organisation dedicated to radio astronomy and is headquartered in the UK.

At the moment, organisations from ten countries are a part of the SKAO.

These include Australia, Canada, China, India, Italy, New Zealand, South Africa, Sweden, the Netherlands and the UK.

#### *What are Radio Telescopes?*

- Unlike optical telescopes, radio telescopes can detect invisible gas and, therefore, they can reveal areas of space that may be obscured by cosmic dust.
- The first radio signals were detected by physicist Karl Jansky in the 1930s.
- The Arecibo telescope in Puerto Rico, which was the second-largest single-dish radio telescope in the world, collapsed in December 2020. The telescope was built in 1963.

#### *About SKA Telescope*

- The telescope is proposed to be the largest radio telescope in the world.
- It will be located in Africa and Australia whose operation, maintenance and construction will be overseen by SKAO.
- The completion is expected to be taken a decade early at a cost of over £1.8 billion.

### Ariel (Atmospheric Remote-Sensing Infrared Exoplanet Large-Survey)

The **European Space Agency (ESA)** has formally adopted **Ariel. Ariel (Atmospheric Remote-sensing Infrared Exoplanet Large-survey)** will be launched in 2029. It will perform **a large-scale survey of over a thousand exoplanets over a period of four years.** The explorer that will **study the nature, formation and evolution of exoplanets.**

#### *Significance*

- Ariel is the **first mission of its kind dedicated to measuring the chemical composition and thermal structures of hundreds of exoplanets.**
- It will also help to answer one of the key questions of ESA's **Cosmic Vision Plan**, which is, **"What are the conditions for planet formation and the emergence of life?".**

#### *How Exoplanets are Found?*

- As per NASA, only a handful of exoplanets have been found using telescopes and the rest have been detected using indirect methods. These include:
- **Tracking the dimming of a star that happens when a planet passes in front of it. NASA's Kepler Space telescope** uses this method to spot thousands of planets.
- **Gravitational lensing and the "wobbling method"**, which is based on the idea that an orbiting planet will cause its parent star to orbit slightly off-centre.

#### *Why Study Exoplanets?*

- The search for exoplanets is driven by the possibility that **life may exist beyond Earth and even if there is no evidence for this**, scientists believe that their hunt for an answer will reveal details about where humans came from and where we are headed.

#### *Key Points*

- As of now the existence of **more than 4,000 exoplanets is considered confirmed**, while there are thousands of other candidate exoplanets that need further observations to say for certain if they are exoplanets.
- **Proxima Centauri b** is the closest exoplanet to Earth, is four light years away and inhabits the **"habitable zone" of its star**, which means that it could possibly have liquid water on its surface.

## 8.14.7 Asteroid Missions in News

### Dawn Asteroid Mission

**Since its launch in the year 2007**, the unmanned spacecraft has travelled 4.3 billion miles (6.9 billion kilometres).

The **only spacecraft ever to orbit a cosmic body in 2011, in the main asteroid belt between Mars and Jupiter when it started orbiting around the asteroid Vesta.**

Dawn, after running out of fuel in 2018, being the only NASA spacecraft launched 11 years ago, that studied two of the largest objects in the asteroid belt, has ended its mission.

### Hayabusa and Hayabusa-2

Hayabusa is an **asteroid sample-return mission** operated by the **Japanese Space Exploration Agency (JAXA).**

**In mid-September 2005, Hayabusa landed on the asteroid Itokawa**, and managed to collect samples in the form of grains of a steroidal material. **It returned to Earth with the samples in June 2010, thereby becoming the first spacecraft to return asteroid samples to Earth for analysis.**

#### *Hayabusa-2*

- It was **launched on 3 December 2014** and rendezvoused with **near-Earth asteroid Ryugu** on 27 June 2018 at 300 million km from Earth's surface.
- **It is in the progression of asteroid surveying for a year and a half, leaving in December 2019, and returned to Earth on 6 December 2020.** The soil samples and data from the asteroid could provide clues to the origins of the solar system.
- **Hayabusa-2 took numerous science payloads for remote sensing, sampling and four small rovers which will examine the asteroid surface so as to update the environmental and geological context of the samples collected.**

### NASA'S OSIRIS-REX

The NASA OSIRIS-REX mission **launch took place on September 8, 2016.** On **20th October 2020, NASA's OSIRIS-REx spacecraft briefly touched asteroid Bennu**, from where it is meant to collect samples of dust and pebbles and deliver them **back to Earth in 2023.**

**NASA's OSIRIS-REX spacecraft has discovered hydrogen and oxygen molecules traces, which being part of the water formula and thus the potential for life.**

**It entrenched in the asteroid Bennu's rocky surface, where it will grab a sample of rock and dust and bring it back to the Earth.**

## 8.14.8 Space Craft Leaving Our Solar System/ Interstellar Mission

### Pioneer 10 & Pioneer 11

Pioneer 10 was launched toward Jupiter on **2 March 1972.** This spacecraft was the first one to fly to Jupiter, Saturn, the Milky Way Galaxy and stars. After Pioneer 10 emerged through the asteroid belt, Pioneer 11 was launched on a similar trajectory on **April 5, 1973**, like Pioneer 10, on top of an Atlas/Centaur/TE364-4 launch vehicle.

Pioneer 10 was the first spacecraft to pass through the asteroid belt, considered a spectacular achievement, and then headed toward Jupiter. Accelerating to a speed of 131,200 kilometres per hour, Pioneer 10 passed by Jupiter on Dec. 3, 1973. The spacecraft was the first to make direct observations and obtain close-up images of Jupiter. Pioneer 10 also took measurements of the gas giant's magnetosphere, radiation belts, magnetic field, atmosphere, and interior. In 1983, Pioneer 10 became the first human-made object to pass the orbit of Pluto, at that time considered the most distant planet from the sun.

Pioneer 10 spacecraft continued to make valuable scientific investigations in the outer regions of the solar system until its science mission ended on **March 31, 1997.**

Pioneer 10, Earth's first emissary into space, is **carrying a gold plaque** that describes what we look like, where we are and the date the mission began. Pioneer 10 will continue to coast silently as a ghost ship through deep space into interstellar space, heading generally for the red star Aldebaran, which forms the eye of the constellation Taurus (The Bull). Aldebaran is about 68 light years away.

Its sister ship, Pioneer 11, ended its mission **September 30, 1995**, when the last transmission from the spacecraft was received.

### Voyager Mission

The NASA's Voyager mission **was launched in the 1970's, to explore the outer planets.**

This probe is **still going in interstellar space.**

- The Voyager Interstellar Mission's (VIM) goal is to expand the NASA solar system exploration ahead of the outer planets neighbourhood to the outer limits of the Sun's sphere of influence, and possibly away from it.
- VIM was launched in **August (Voyager 2)** and **September (Voyager 1), 1977** from **Cape Canaveral, Florida**. Voyager 1 was at a distance of approximately 40 AU (Astronomical Unit – mean distance of Earth from the Sun, 150 million kilometres) from the Sun, and Voyager 2 was at a distance of approximately 31 AU, after **completion of its 12 years journey till 1989.**
- **On August 25, 2012, Voyager 1 flew beyond the heliopause and entered interstellar space, making it the first human-made object to explore this new territory.**

  **Voyager 2, which is travelling in a different direction from Voyager 1, crossed the heliopause into interstellar space on November 5, 2018.**
- The Voyagers have enough electrical power and thruster fuel to keep its current suite of science instruments on **until at least 2025.** By that time, Voyager 1 will be about 22.1 billion kilometres from the Sun and Voyager 2 will be 18.4 billion kilometres away.

### New Horizons

**[Launch Date: 19 January 2006, Launch Site: Cape Canaveral]**

It was launched by NASA, being an interplanetary space probe. The primary objective was to make the study of Pluto and a secondary mission in fly by study of one or more other Kupier belt objects.

- In January 2015: It started its approach towards Pluto. In July 2015, it flew 12,500 kilometres above the surface of Pluto to make it the first spacecraft to explore the dwarf planet.
- New Horizons was saluted for accomplishing the **first direct investigation of Kupier belt objects.**
- At Pluto, New Horizons found **signs of ice volcanoes, giant mountains,** and even a **liquid water ocean.** Then, the probe pushed on into the depths of the Kuiper Belt, where it **explored 486958 Arrokoth,** a primordial world of ice and rock that looks like two pancakes stuck together.
- But unlike its interstellar spacecraft kin, New Horizons doesn't carry a plaque or a golden record designed to teach aliens about the human race. And that was intentional.
- The New Horizons mission is currently extended through 2021 to explore additional Kuiper Belt objects.

## 8.14.9 Important Moon Mission

**In Progress**

- China's **Chang'e-5** returned lunar samples to Earth in 2020, and is on an extended mission to study the Sun and possibly asteroids.
- India's **Chandrayaan-2** orbiter maps the Moon's topography, studies its composition, and scans for water ice.
- China's **Chang'e-4** performed the first landing on the Moon's far side in 2018, where it studies an ancient region.
- NASA's **Lunar Reconnaissance Orbiter** studies the Moon with a high-powered camera.

**Coming Soon**

- NASA's VIPER rover launches to the Moon's south pole in 2024 to study water ice.
- Israeli non-profit SpaceIL launches Beresheet 2 to the Moon in 2024 to conduct scientific experiments and public outreach.

### Lunar Reconnaissance Orbiter (LRO)

**LRO** and the **Lunar** Crater Observation and Sensing Satellite (LCROSS) **were** launched on an Atlas V rocket on June 18, 2009, beginning a four-day trip to the **moon. LRO** spent its first three years in a low polar **orbit** collecting detailed information about the **moon** and its environment. After this initial orbit, LRO transitioned to a stable elliptical orbit, passing low over the lunar south pole. With a suite of **seven powerful instruments,** LRO has collected a treasure trove of data, making an invaluable contribution to our knowledge about the moon. With the Lunar Reconnaissance Orbiter (LRO), NASA has returned to the moon, enabling new discoveries and bringing the moon back into the public eye.

LRO is a robotic mission that set out to map the moon's surface and, after a year of exploration, was

extended with a unique set of science objectives. LRO observations have enabled numerous ground breaking discoveries, creating a new picture of the moon as a dynamic and complex body. These developments have set up a scientific framework through which to challenge and improve our understanding of processes throughout the solar system.

### Chang'e Mission

The Chinese **Lunar Exploration Program is designed to be conducted in four phases**.

**Phase-1:** Simply reaching lunar orbit, a task completed by Chang'e 1 in 2007 and Chang'e 2 in 2010.

**Phase-2:** Landing and roving on the Moon, as Chang'e 3 did in 2013 and Chang'e 4 did in 2019.

**Phase-3:** Collecting lunar samples from the **near-side** and sending them to Earth, with the help of Chang'e 5 **launched on 24 November 2020** and Chang'e 6 missions in future.

**Phase-4:** Consists of development of a robotic research station near the Moon's South Pole.

### *Chang'e-4 Mission*

Chang'e-4 mission achieved **humanity's first soft landing on the far side of the Moon, on 3 January 2019.** This mission will attempt to determine the age and composition of an unexplored region of the Moon, as well as develop technologies required for the later stages of the program.

### *Objectives*

An ancient collision event on the Moon left behind a very large crater, called the Aitken Basin, that is now about 13 km (8.1 mi) deep, and it is thought that the massive impactor likely exposed the deep lunar crust, and probably the mantle materials. If Chang'e 4 can find and study some of this material, it would get an unprecedented view into the Moon's internal structure and origins.

**China has launched Chang'e-4, a first probe ever to explore the dark side of the Moon, marking another milestone in its ambitious space programme.**

- The Moon is **tidally locked to Earth**, rotating at the same rate at which it orbits our planet, so the remote side is never visible from Earth. The probe, the Chang'e-4, is projected to make the first-ever soft landing on the far side of the Moon. Previous spacecraft have seen the Moon's far side, but none has landed on it.
- The Moon's **far side termed as 'South Pole Aitken Basin'** still remains a mystery among space scientists and by sending a probe there, China will outshine the US and USSR historical achievements.
- Chang'e 4 is the country's fourth mission in the series of lunar mission which is being named after the **Chinese Moon goddess.**
- The main problem faced by the Chinese team will be **difficulties in communication as they attempt to land on the Moon's other side.** China is anticipated for consideration of using options such as **radio telescopes for communicating in the absence of a transmitting medium.**

**YUTU 2**

China has named the **lunar rover**, successfully deployed to carry out a string of experiments on the far side of the Moon, as 'Yutu-2'. The rover's touchdown is part of China Chang'e-4 lunar probe.

**Key Facts**

- **The rover has been programmed to launch ground penetration radar that would help map the Moon's inner structures.**
- **It would also analyse soil and rock samples for minerals, apart from activating a radio telescope to search for possible signals from deep space.**

### *Chang'e-5 Probe*

The Chang'e-5 was **launched on 24 November 2020** and a lander vehicle **touched down on the moon on 1 December 2020**. The mission was expected to take around 23 days in total. **The objective of the mission was to bring back lunar rocks, the first attempt by any nation to retrieve samples from the moon in four decades.**

- Chang'e 5, collected 1,731 gram (Approx. 2 kg) of lunar samples (including from a core 1 m deep), and returned to the Earth on 16 December 2020.
- Chang'e-5 mission is the first lunar sample-return mission conducted by humanity in **over four decades since the Soviet Union's Luna 24 in 1976.**
- **Chang'e 5** is the fifth lunar exploration mission of the Chinese Lunar Exploration Program, and China's first lunar sample-return mission.

*About the Chang'e-5 Probe*

- The probe is named after the mythical Chinese moon goddess.
- The rocket is comprised of four parts: an orbiter, a returner, an ascender and a lander.
- The objective of the mission is to bring back lunar rocks, the first attempt by any nation to retrieve samples from the moon in four decades.
- If successful, China will be only the third country to have retrieved samples from the moon, following the U.S. and the Soviet Union in the 1960s and 1970s.
- This will help scientists learn about the moon's origins, formation and volcanic activity on its surface.

### Artemis Program – Moon

**Artemis-Acceleration, Reconnection, Turbulence and Electrodynamics of Moon's Interaction with the Sun.** It is **NASA's next mission to the Moon.**

- With the Artemis program, **NASA will land the first woman and next man on the Moon by 2024. Artemis was the twin sister of Apollo** and **goddess of the Moon in Greek mythology.**

*Objective*

- To measure what happens when the Sun's radiation hits our rocky moon, where **there is no magnetic field to protect it.**

### NASA's VIPER Mission

NASA has chosen a landing site for the Volatiles Investigating Polar Exploration Rover (VIPER). The site is on the western edge of **Nobile crater**, near the lunar South Pole. The crater was named after Italian polar explorer **Umberto Nobile.**

*Background*

- NASA, in July 2021, announced that it will launch its **Volatiles Investigating Polar Exploration Rover, or VIPER** in 2023.
- NASA is undertaking the mission to understand if it is possible for human life to sustain there, by using locally available resources.

*About the Mission*

- VIPER is a mobile robot.
- It is **the first resource mapping mission on any other celestial body.**
- NASA's Commercial Lunar Payload Services (CLPS) will be providing the launch vehicle and lander for what's going to be a 100-day mission.

*Objectives of the Mission*

- To explore the Moon's South Pole region.
- Help create lunar resource maps.
- Evaluate the concentration of water as well as other potential resources on its surface.

*Significance of the Mission*

- VIPER's findings will inform "future landing sites under the Artemis program by helping to determine locations where water and other resources can be harvested" to sustain humans over extended stays.

## 8.14.10 Miscellaneous Missions in News

### China's Artificial Moon Project

China is in the process of creating an "artificial moon" that would be bright **enough to replace the streetlights in the south-western city of Chengdu by 2022.**

- Chinese scientists intend for **sending three artificial Moons to space** in the **coming four years**, where **reflective material such as a mirror is estimated to orbit at 500 kilometres above the Earth** and **light up an area with a diameter of 10 to 80 kilometres.**
- There will be a **reflective coating on an artificial Moon** which can deflect sunlight back to Earth, akin to how the moon shines.
- The **enlightened satellite is said to be eight times brighter than the real Moon.**
- The three artificial moons would function alternately for significantly reducing infrastructural electricity consumption, especially at the time of winter. The illuminated satellite is intended to complement the moon at night.
- **Every year, light from the artificial moon in Chengdu covering 50 square kilometres could possibly save about 1.2 billion yuan ($240 million) in electricity costs.**
- It could also be used to lighten up the areas experiencing power breakdown due to **natural disasters such as earthquakes.**

Note: The thought for the artificial human made moon began from a French artist who imagined hanging a necklace in the sky made of mirrors for lightening up the Paris streets at night. Russia tried to initiate a 25-metre "space mirror" but the project was suspended in the year 1999.

### NASA'S Orion Spacecraft

NASA's Orion spacecraft is **designed to carry humans further than they've ever gone before.**

Orion will function as the exploration vehicle which will take the crew to space, **provide capability for emergency abort**, sustain the crew at the time of travelling to space, and **provide safer re-entry from deep space return velocities.** Orion will be launched from NASA's new heavy-lift rocket, the System for Space Launch.

NASA has successfully finished the last test for qualifying Orion's space capsule's parachute system for onboard flights with astronauts, ahead of its mission in sending humans to the Moon and beyond.

The parachute system is the lone system that must assemble itself in mid-air and must be able to keep the crew safer in scenarios of numerous failures, for instance mortar failures which avoid deploying a single parachute type, or circumstances causing the failure of some of the components of parachute textile.

### ICESAT and ICESAT-2

**ICESat (Ice, Cloud and land Elevation Satellite) mission** was sent for **measuring ice sheet mass balance, cloud and aerosol heights, land topography and vegetation characteristics as an Earth Observing System.**

The Ice, Cloud and land Elevation Satellite-2 (ICESat-2) is the 2nd-generation of the laser altimeter ICESat-1 mission (January 13, 2003 to August 14, 2010).

ICESAT 2 was launched on 5 September 2018 from Vandenberg Air Force Base in California, into a near-circular, near-polar orbit with an altitude of approximately 496 km.

It was designed to operate for three years and carry enough propellant for seven years.

- NASA's ICESat-2 **will map ice sheets melting in Antarctica and the resulting rising sea level across the globe, thereby assisting in the improvement of climate forecasts.**
- **The satellite is measuring the sea ice height to inside an inch**, tracing the unmapped Antarctic valleys terrain, surveying of remote ice sheets, and peering through forest canopies and shallow coastal waters.

### ICON Mission

**National Aeronautics and Space Administration (NASA)** has launched a satellite ICON to **detect dynamic zones of Earth's Ionosphere**. The satellite **Ionosphere Connection Explorer (ICON)** was **launched from** an aircraft over the Atlantic Ocean near the **Florida coast on 11 October 2019** with **two years lifespan.** The ICON satellite will study the Earth's Ionosphere. **It includes various layers of the uppermost atmosphere where free electrons flow freely.**

### Sentinel-6 Satellite

The **Copernicus Sentinel-6 Michael Freilich satellite** is designed to monitor oceans. It was launched on **22 November 2020** from California aboard a **SpaceX Falcon 9 rocket.** This is **a part of the next mission dedicated to measuring changes in the global sea level.**

#### *What is the Mission?*

- The mission is called **the Jason Continuity of Service (Jason-CS) mission.**
- It is designed **to measure the height of the ocean,** which is a key component in understanding how the Earth's climate is changing.
- It has been **developed jointly by** the ESA, NASA, European Organisation for the Exploitation of Meteorological Satellites (Eumetsat), the USA's National Oceanic and Atmospheric Administration (NOAA) and the EU, with contributions from France's National Centre for Space Studies (CNES).

#### *What will the Satellite do?*

- Provide measurements of global sea-level rise.
- Send pulses to the Earth's surface and measure how long they take to return to it, which will help scientists measure the sea surface height.
- Measure water vapour along this path and find its position using GPS and ground-based lasers.

#### *Significance of the Mission*

- This data will allow improvements in both short-term forecasting for weather predictions in the two-to-four-week range (hurricane intensity predictions), and long-term forecasting, for

instance for seasonal conditions like **El Niño and La Niña**.

***Why is it important to measure the height of the ocean?***

1. With this, it is possible to observe the height of the oceans on a global scale and monitor critical changes in ocean currents and heat storage only from space.
2. It helps scientists foresee the effects of the changing oceans on the climate.
3. In order to measure and track changes in the oceanic heat budget, scientists need to know the ocean currents and heat storage of the oceans, which can be determined from the height of the sea surface.

**Other satellites that have been launched since 1992 to track changes in the oceans on a global scale include:** The TOPEX/Poseidon, Jason-1 and OSTN/ Jason-2, among others.

### Spacex Launches 143 Satellites, Breaks World Space Record

- Space-X broke a world space record by launching 143 satellites in quick succession, beating India's record of deploying 104 satellites in February 2017. The launch vehicle for the Space-X record-breaking flight was the Falcon 9 and the mission was designated as **Transporter-1**.
- The launch marks **the first dedicated mission for Space-X's Small Sat Ride share Program**, which enables small-satellite customers to book a ride to orbit with Space-X directly.

### Russia to Launch its Own Space Station in 2025

Russia's space agency is planning to launch its own **orbital station in 2025**. Russia is considering withdrawing from **the International Space Station programme** to go it alone. Russia lost its monopoly for manned flights to the ISS last year after the first successful mission of U.S. company Space X.

***About the International Space Station***

- Launched in **1998** and **involving Russia, the United States, Canada, Japan, and the European Space Agency**, the ISS is one of the most ambitious international collaborations in human history.
- ISS is a modular space station (habitable artificial satellite) in low Earth orbit.
- The ISS serves as a microgravity and space environment research laboratory in which scientific experiments are conducted in astrobiology, astronomy, meteorology, physics, and other fields.
- The ISS circles the Earth in roughly 93 minutes, completing 15.5 orbits per day.
- **ISS is the ninth space station to be inhabited by crews**, following the Soviet and later Russian Salyut, Almaz, and Mir stations as well as Skylab from the US.

### Inspiration4: SpaceX's First All-Civilian Space Mission

- **The mission involves circling the Earth for three days**, and then splashing down into the Atlantic Ocean. Inspiration4 **will orbit the Earth at 575 km**, higher than **the International Space Station** (408 km) and **the Hubble space telescope** (547 km). This **will be the farthest distance travelled by a crewed mission since 2009**, when astronauts last went to repair the Hubble.

***Why is the journey significant?***

- According to the reports, the journey **will present an opportunity for collecting large amounts of health data** that will aid in planning future crewed space missions.
- This will also help in assessing behavioural and cognitive changes over the journey.
- Along with the **recent space journeys by billionaires Jeff Bezos and Richard Branson**, Inspiration4 is seen as part of an effort to open up space travel to non-professionals.

***Facts***

- Entrepreneur Elon Musk's SpaceX announced **'Inspiration4', its first all-civilian, non-governmental spaceflight** on 16 September 2021.
- The **Crew Dragon spacecraft** was launched from **NASA's Kennedy Space Centre in Florida in the US**.
- It took a **group of four private citizens into space for three days**.
- All four seats on the spacecraft were **purchased by US billionaire Jared Isaacman**, founder of the fintech company Shift4 Payments.
- This was a part of an **effort to raise millions for the Tennessee-based St. Jude Children's Research**

**Hospital**, a paediatric treatment and research facility that focuses on children's catastrophic diseases, particularly leukaemia and other cancers.

## 8.14.11 Commercial Crew Program

### Crew Mission

The main objective of this program is to make access to space easier in terms of its cost, so that cargo and crew can be easily transported to and from the ISS, enabling greater scientific research. Through this program, NASA plans to lower its costs by sharing them with commercial partners such as Boeing and SpaceX, and also give the companies incentive to design and build the Commercial Orbital Transportation Services (COTS).

#### *Crew-1 Mission*

**Crew-1 is the first of six crewed missions that NASA and SpaceX will operate as part of the Commercial Crew Program, whose objective is to make access to space easier in terms of cost.**

The mission was launched on 16 November 2020. Crew-1 is the first operational flight of the SpaceX Crew Dragon spacecraft on a Falcon 9 rocket to the ISS and is also the first of the three such flights scheduled over the course of 2020–21.

#### What will members of Crew-1 do at the ISS?

- The Crew-1 team will conduct microgravity studies.
- Some of the research that the crew is carrying with themselves includes materials to investigate food physiology, which will study the effects of dietary improvements on immune function and the gut micro-biome and how those improvements can help crews adapt to spaceflight.
- Once in orbit, astronauts will collect samples to provide data to scientists back on Earth so that they can continue to study how dietary changes affect his body.
- Another experiment aboard is a student-designed experiment titled, "**Genes in Space-7**" that aims to understand how spaceflight affects brain function.

#### *Crew-2 Mission*

**Four astronauts are sent** to the International Space Station (ISS) from Florida through a collaboration program of NASA and SpaceX under the Commercial Crew Program.

**SPACEX WILL LAUNCH NASA'S UPCOMING CREW-1**

- NASA has certified **SpaceX's Crew Dragon capsule and the Falcon 9 rocket**, making it **the first spacecraft certification provided by the space agency.**
- This means **SpaceX can now operate regular flights to the space station.**
- **SpaceX's Crew Dragon spacecraft** lifted off from NASA's Kennedy Space Centre in Florida on November 14, 2020.

### Background

- The Crew-2 mission is the **second of six crewed missions NASA and SpaceX** will fly as part of the agency's Commercial Crew Program.
- This mission has several firsts, including:
  - First commercial crew mission to fly two international partners.
  - First commercial crew handover between astronauts on the space station as Crew-1 and Crew-2 **astronauts will spend about five days together on station before Crew-1 returns to Earth.**
  - **First reuse of the Crew Dragon spacecraft and Falcon 9 rocket on a crew mission** – Crew Dragon Endeavour flew the historic Demo-2 mission and the Falcon 9 flew astronauts on the Crew-1 mission.
  - **First time two commercial crew spacecraft will be docked to station at the same time.**

#### *What is the Crew-2 Mission?*

- The mission is second crew rotation of the SpaceX Crew Dragon and is first with international partners.
- It is a six-month science mission.
- Astronauts include **two from NASA and one each from JAXA and ESA.**
- NASA's SpaceX Crew-2 mission consist a rocket booster that is recycled from a previous spaceflight.
- **The Falcon 9 rocket used in the Crew-2 mission was used to launch the Crew-1 into orbit five months ago.** This marks the **first time a previously flown rocket booster is re-used in a crewed launch.**
- The latest mission is the second "operational" space station team that was launched by NASA aboard a Dragon Crew capsule.

*What will Crew-2 do at ISS?*

- Crew-2 astronauts will join the members of Expedition 65.
- They will stay aboard the ISS for six months and will conduct science experiments in low-Earth orbit.
- Their central focus will be to continue a series of Tissue Chips in Space studies.

- Tissue Chips are small models of human organs that contain multiple cell types that behave similarly to the human body.
- These chips can speed up the process of identifying safe and effective drugs and vaccines.
- Scientists will use these tissue chips in space to study diseases that affect specific human organs.
- The main advantage is that experiments in space takes lesser times in comparison to earth.

## 9.1 MINISTRY OF COMMUNICATION AND INFORMATION TECHNOLOGY

The Ministry of Communication and Information Technology plays the leading role in Information and Communication Technology (ICT) regulation in the country with three associated departments: Department of Telecommunications (DoT), Department of Information Technology and Department of Posts.

## 9.2 DEPARTMENT OF TELECOMMUNICATION (DOT)

Its responsibilities include:

- Policy formulation; performance evaluation and review; monitoring; international cooperation; research and development and grant of licences to operators.
- Allocation of frequency and management of radio communications in close coordination with the international bodies.
- In recent years, **Indian telecom sector has grown at a steady rate and thus accords as the second largest telephone network in the world after China.**

## 9.3 REGULATORY FRAMEWORK-TRAI AND TDSAT

At the first level of telecom dispute, matter is sent to TRAI (established in 1997) to resolve it. If TRAI could not resolve this issue, it will transfer to Telecom Dispute Settlement Appellate Tribunal. An ordinance amending TRAI Act led to the establishment of TDSAT for taking over the functions related to TRAI's arbitration and disputes, effective from 24 January 2000. Its primary aim was to adjudicate any dispute between licensor and a licensee, between two or more service providers and a consumers group and further appeals hearing and disposing against TRAI directions, decisions or orders. If TDSAT could not resolve this issue, Supreme Court's decision will be the final decision and mandatory for everyone.

### *Composition of TDSAT*

- The Tribunal composed of a Chairperson and two members selected by the Central Government.
- The **Chairperson** should be or should have been a Supreme Court Judge or the High Court Chief Justice.
- A **member** should have held the Secretary post to the Government of India or any equivalent post in the Central Government or the State Government

### TELECOM REGULATORY AUTHORITY OF INDIA (TRAI)

Telecom Regulatory Authority of India (TRAI) was established on 20 February 1997 with the mission, to create and nurture conditions for the growth of telecommunications in India.

The main objectives of TRAI are to provide a fair and transparent environment in the market. TRAI regularly issues orders and directions on tariffs, interconnections, quality of services, Direct To Home (DTH) services and mobile number portability, etc.

From 1st January 2016, consumers have been compensated for call drops under TRAI Rule. In this case mobile users got compensation of ₹1 for every dropped call but it was limited to a maximum three dropped calls in a day.

TRAI is administered through a Secretariat headed by a secretary to organise the agenda for Authority meetings. (Consulting with the Chairman), prepares the minutes and issues regulations in accordance to the meetings.

**TRAI launched three new apps** (Mycall app, MySpeed app and 'Do not disturb' (DND 2.0) apps) and a **web portal** to ensure that the users are fully aware of the telecom services that are being offered to them, on 6 June 2017.

TRAI always tries to maintain transparency between what consumers are paying for and what telecom operators are promising to provide at a certain rate.

TRAI released their new app on 28 December 2018, called "'TRAI CHANNEL SELECTOR"' app. By using this app, we can add, remove and manage our channels.

In order to increase broadband penetration in India, TRAI has proposed WANI **(Wi-Fi Access Network Interface)** architecture which has been launched in August 2022 in Dehradun. It may lead to set up of Public Data Offices (PDOs) where Wi-Fi Internet would be available on demand.

for a period of not less than two years or a person who is well versed in the field of technology, telecommunication, industry, commerce or administration.

### PM-WANI

- Public Wi-Fi plan 'PM Wani' approved in December 2020.
- The move is aimed at helping accelerate the uptake of broadband Internet services.
- It was first recommended by the Telecom Regulatory Authority of India (TRAI) in 2017.

**Key Features**

1. This has set up public Wi-Fi hotspots across the country via public data offices (PDOs).
2. It will not require the PDOs to get a license or pay a fee.
3. This will involve multiple players, including PDOs, Public Data Office Aggregators (PDOA), App Providers and a Central Registry.

**Implementation:**

1. PDOs will be 'facilitators' between service providers and users.
   A PDOA will be an aggregator of PDOs that will oversee functions relating to authorisation and accounting of Wi-Fi connections.
3. A person, who wants to use public Wi-Fi, can do so via an app and will make payments as per usage.
4. The project will also have an app developer who will build a platform to register users and discover Wani-compliant Wi-Fi hotspots in an area and display them on the app.
5. A central registry, which will be maintained by the Centre for Development of Telematics, will record the details of app providers, PDOAs and PDOs.

**Significance of the Project**

Public Wi-Fi networks will 'democratise' content distribution and broadband access to millions at affordable rates. This will be the UPI (unified payments interface) of connectivity services.

## 9.4 IT RULES, 2021

- It mandates **a grievance redressal system** for over the top (OTT) and digital portals in the country. This is necessary for the users of social media to raise their grievance against the misuse of social media.
- **Significant social media firms** have to appoint **a chief compliance officer** and have **a nodal contact person** who can be in touch with law enforcement agencies 24/7.
- **A grievance officer:** Social media platforms will also have to name **a grievance officer** who shall register the grievance within 24 hours and dispose of it in 15 days.
- **Removal of content:** If there are complaints against the dignity of users, particularly women – about exposed private parts of individuals or nudity or sexual act or impersonation etc. – social media platforms will be required to remove that within 24 hours after a complaint is made.
- **A monthly report:** They also will have to publish a monthly report about the number of complaints received and the status of redressal.
- There will be three **levels of regulation for news publishers** – self-regulation, a self-regulatory body, headed by a retired judge or an eminent person, and oversight from the Information and Broadcasting Ministry, including codes of practices and a grievance committee.

### *Significant Social Media Intermediary and its Benefits*

Social media companies with more than 50 lakh registered users will be considered 'significant social media intermediaries', as per the new norms.

### *What happens in case of noncompliance?*

- Social media giants such as Facebook, Twitter, Instagram and WhatsApp messenger **could face a ban** if they do not comply with the new Information Technology rules.
- They also run the risk of losing their status as '**intermediaries**' and may become liable for criminal action if they do not comply with the revised regulations.

### Recent Updates

### *2022 Notified Amendments*

- Intermediaries must ensure compliance with rules and regulations, privacy policy and user agreement, and make reasonable efforts to cause users to not create, upload or share prohibited content. They must also respect the Constitutional rights of users.
- The central government will establish one or more Grievance Appellate Committee to hear appeals against the decisions of grievance officers.

*2023 Draft Amendments*

- The draft Amendments propose to prohibit false/fake information and also regulate online gaming.
- Intermediaries must remove any information identified as false or fake by the fact check unit of the Press Information Bureau (PIB), or any other centrally authorised agency from their platforms, to avoid liability for such content.
- Online games are defined as games played on the internet with a deposit and the expectation of a winning. An online gaming intermediary has to ensure additional due diligence such as displaying a random number generator and a no-bot certificate.
- Self-regulating bodies (SRBs) will also be empowered to regulate the content of registered games. SRBs must evolve a framework to test, verify and register games such that the sovereignty, integrity and security of the country is secured.

## 9.5 DEPARTMENT OF ELECTRONICS AND INFORMATION TECHNOLOGY

**Vision** Developing India as the engine for transition into a developed nation and an empowered society.

**Mission** e-Development of India through multi-pronged strategy of e-infrastructure creation to facilitate and promote e-governance, providing support for the Innovation/Research and Development (R&D), promotion of Electro Information Technology – Information Technology-Enabled Services (IT-ITeS) Industry, securing India's cyber space and building knowledge network.

*Objectives*

- **e-Government:** To provide e-infrastructure for delivery of e-services.
- **e-Industry:** To promote electronics manufacturing and IT-ITeS industry.
- **e-Innovation/Research and Development:** To provide support for creation of Innovation Infrastructure in the emerging areas of technology
- **e-Education:** To provide support for development of e-skills and knowledge network.
- **e-Security:** To secure India's cyber space.

## 9.6 COMPUTER EMERGENCY RESPONSE TEAM (CERT-IN)

It works under the Ministry of Electronics and Information Technology, deals with cyber security and serves as the national agency to perform certain functions.

**It intends to perform these duties:**

- Identify cyber incidents and issue information regarding it.
- Raise alerts for cyber security incidents.
- Emergency measures to act during cyber security incidents.
- Coordination of cyber incident response activities.
- Issuance of guidelines, advisories, vulnerability notes and white papers relating it.
- The incidents are reported on daily basis and alerts computer system users about the vulnerability of the system. Recently, multiple vulnerabilities in Apple iOS were detected and reported by it.
- CERT report new viruses and malwares time to time.

**APCERT** APCERT (Asia Pacific Computer Emergency Response Team) is a coalition of CSIRTs (Computer Security Incident Response Teams), from 13 economies across the Asia Pacific region. APCERT organises an annual meeting called APSIRC conference, and the first conference was held in March 2002, Tokyo, Japan.

**NATIONAL ASSOCIATION OF SOFTWARE AND SERVICES COMPANIES (NASSCOM)**

It is an Indian trade organisation on Information Technology (IT) and Business Process Outsourcing (BPO) industry and was set-up in 1988, as a non-profit organisation. NASSCOM encourages software and services business and trade and the research enhancement in software technology. It is listed under the Indian Societies Act, 1860 and has regional offices in Bengaluru, Chennai, Hyderabad, Kochi, Kolkata, Mumbai, Pune and Thiruvananthapuram. The international IT trade body has more than 2000 members, of which more than 250 are companies from the China, EU, Japan, US and UK. NASSCOM's associate companies are in the dealing with software development, its services, products, IT-enabled/BPO services and e-commerce services.

## 9.7 BHARAT BROADBAND NETWORK/ BHARATNET/NATIONAL OPTICAL FIBRE NETWORK (NOFN)

The Government of India approved the National Optical Fibre Network (NOFN) initiative on **25 October 2011**. Under BharatNet Project there were provision to extend **optical fibre network to connect all 250,000 gram panchayats in the country covering nearly 625,000 villages.** On 25 February 2012 under Companies Act of 1956, a Special Purpose Vehicle (SPV) was incorporated to make this project successful as soon as possible. But still, between 2011 and 2014, project did not take off as planned, and only 350 km of optical fibre, out of 300,000 km optical fibre network needed for the Phase-I, was laid. **Between 2014 and 2017, the original Phase-I target of laying 300,000 km of optical fibre was completed.**

**The BharatNet project picked up pace under the Digital India initiative,** made several changes to expedite the project, significantly enhanced the BharatNet funding to several billion dollars under the Digital India, appointed government public sector units (BSNL, RailTel, and PowerGrid Corp) for the swift implementation and monitoring.

Note: **Idukki** district of Kerala became the first district in India to have high-speed Rural Broadband Network, i.e., National Optical Fibre Network (NOFN) Internet connectivity. In Idukki, 8 block offices and 52 village panchayats out of 53 will benefit from this project.

### Recent Updates

Union Cabinet has accorded approval for the revised implementation strategy of **BharatNet** through **Public-Private Partnership (PPP)** mode in 16 states of the country.

#### *The strategy includes*

1. The government will provide ₹19,041 crore as **viability gap funding** for the project.
2. BharatNet will now **extend up to all inhabited villages beyond the gram panchayats (GPs)** in the said states.
3. It includes creation, upgradation, operation, maintenance and utilisation of BharatNet by the concessionaire who will be selected by a competitive international bidding process.

#### *Significance*

- The PPP model will leverage private sector efficiency for operation, maintenance, utilisation and revenue generation, and is expected to result in a faster rollout of BharatNet.
- Extension of reach of BharatNet to all inhabited villages with reliable, quality, high speed broadband will enable better access of e-services offered by various central and state government agencies.
- It will also enable online education, telemedicine, skill development, e-commerce and other applications of broadband.

#### *The larger vision of the project is*

- To establish a highly scalable network infrastructure accessible on a non-discriminatory basis.
- To provide on demand, affordable broadband connectivity of 2 Mbps to 20 Mbps for all households and on demand capacity to all institutions.
- To realise the vision of Digital India, in partnership with States and the private sector.

#### *Implementation*

- The project is **a Centre-State collaborative project**, with the States contributing free Rights of Way for establishing the Optical Fibre Network.
- The entire project is being funded by **Universal service Obligation Fund (USOF)**, which was set up for improving telecom services in rural and remote areas of the country.

#### *Importance of BharatNet*

- The World Bank conducted a study, which stated that there is a 1.4% increase in GDP growth with every 10% increase in broadband penetration.
- The implementation of various e-governance initiatives such as e-health, e-banking and e-education, will be facilitated by NOFN, thereby enhancing inclusive growth.

#### *Education*

- Remote classrooms in rural government schools: Online vocational training courses delivered through rural ICT centres such as the Common Service Centres.

*Healthcare*

- Telemedicine centres for remote consultation and diagnostics, set up by private healthcare service providers or by rural entrepreneurs in collaboration with private healthcare service providers.

*Banking*

- Basic banking services to the unbanked population using, among others, the Post Office network.
- Doorstep banking services from various commercial banks through the Business Correspondent network maintained by a third-party private provider.

*Agriculture*

- Internet kiosks for providing agriculture-related information to farmers.
- Integrated application platform that pushes agricultural information over SMS and can also be accessed.

## 9.8 KERALA FIBRE OPTIC NETWORK PROJECT

The ***Kerala Cabinet*** has approved an ₹1,548-crore ***fibre-optic network project.*** With the inauguration of its first phase in ***February 2021***, the project seeks to fulfil the government's aim of making Internet access a '***citizen's right***'.

*About the fibre-optic network project*

**Objective** To provide free high-speed Internet connection to around 2 million families in the state.

- Aims **to provide free high-speed Internet to over 20 lakh below poverty line (BPL) households.**
- It is ***a collaborative initiative*** of the state's power utility Kerala State Electricity Board and Kerala State IT Infrastructure Ltd.
- Internet service providers and cable television operators can also join the optic-fibre network project to provide their services.
- As many as 30,000 government offices and schools would be linked through the high-speed network, said the state government.

*Significance*

- The project is expected to help the country's IT industry and open major opportunities in the fields of artificial intelligence, blockchain, and start-ups. It is also expected to help in better management of the transport sector.

## 9.9 CENTRE FOR DEVELOPMENT OF TELEMATICS (C-DOT)

- The telecom technology development centre of GOI is named as C-DoT, which was established in 1984 as an autonomous body.
- Meant to provide a wide range of cost-effective indigenously developed and state-of-the-art total telecom solutions – satellite communications, IN, wireless broadband, GPON, NGN, ATM DWDM, NMS, and mobile cellular system.

*Telematics*

- Telematics, as an interdisciplinary field, includes telecommunications, road safety, vehicular technologies, road transportation, electrical engineering (sensors, instrumentation, wireless communications, etc.) and computer science (multimedia, Internet, etc.)
- This system is a suite of services powered by wireless communications, global positioning systems and on-board electronics. Telematics systems facilitate Internet and wireless cellular services that assist in services for location, navigation, traffic monitoring and control, toll collection, safety and traveller information.
- The technology enables sending, receiving and storing information via telecommunication devices in conjunction with affecting control on remote objects.
- Global Navigation Satellite System (GNSS) technology integrated with computers and mobile communications technology in automotive navigation systems.
- The integrated use of telecommunications and informatics for application in vehicles.
- When used within road vehicles, it is also called vehicle telematics.

## 9.10 TELECOM PUBLIC SECTOR UNDERTAKINGS

Department of Telecommunication has four PSUs under its administrative control:

I. **Indian Telephone Industries Limited (ITI):** ITI Limited was incorporated as the first PSU in the country, by the DoT in 1950. Its headquarters is in Bengaluru, with manufacturing plants at Naini, Raebareli and Manka in UP, Palakkad in Kerala, and Srinagar in Jammu and Kashmir. ITI Limited was the sole equipment supplier to DoT and later to the corporatized entities, BSNL and MTNL, until the early nineties.

II. **Telecommunications Consultants India Limited (TCIL):** A wholly Government of India-owned enterprise (which was set up in March 1978).
Main objectives include:
- Globally enabling the world-class expertise and technology to the country, in all telecommunications and information technology fields.
- With the help of proper strategies of market development, there is a need to sustain, expand and excel in its overseas/Indian markets operations.
Consistently acquiring the state-of-the-art technology and further maintaining its leadership.
- Diversify into Cyber Parks, Cyber Cities, Intelligent Buildings, Highways and Roads and other civil works.
- In order to build new telecom and networks, there is a need to have cost-effective network technologies and further upgradation of legacy networks.
- Focussing on Broadband Convergent Service Multimedia Networks.
- System integration in telecom billing, e-Governance networks, customer care, and value-added services.
- Promotion of operation and management contracts overseas through the utilisation of technical expert manpower in the IT and Telecom fields (Theoretical and Computational Issues in Lexical Semantics).
- Development of latest IT and Telecom training infrastructure in the overseas markets.
- Aggressive participation in State Wide Area Network (SWAN) projects in various states.

III. **Mahanagar Telephone Nigam Limited:** It was first set up as a Navratna PSU in 1986. The primary objective is to expand quality telecom network and raise revenue for developing telecommunication facilities in India's key metros – Delhi and Mumbai. It acted as the forefront of technology induction by conversion of 100% of its telephone exchange network into the state-of-the-art digital mode. As of June 2022, Mahanagar Telephone Nigam Limited (MTNL) had 2.15 million wireless subscribers in Delhi. Mumbai had over a million MTNL GSM users. Mahanagar Telephone Nigam Limited (MTNL) services were only available in Mumbai and Delhi region.

IV. **Bharat Sanchar Nigam Limited:** A comprehensive range of telecom services, viz., wire line, CDMA wireless, GSM wireless, Internet, Broadband, Carrier service, MPLS-VPN, VSAT, VoIP services, IN services, etc., are provided by BSNL, which was formed in 2000, throughout India except Delhi and Mumbai. The rural telephone system is one of the focus areas of BSNL and thus, it has remarkably provided Village Public Telephones (VPTs) in 5.82 lakh villages, as on 31 May 2013. It also introduced broadband services from January 2005, and as per TRAI Press Release 13/2023, BSNL was one of the top five service providers constituting 98.41% market share of the total broadband subscribers at the end of December-22. These service providers were Reliance Jio Infocomm Ltd (432.16 million), Bharti Airtel (234.46 million), Vodafone Idea (123.87 million), BSNL (26.35 million) and Atria Convergence (2.14 million)

## 9.11 DIGITAL CONVERGENCE AND COMMUNICATION COMMISSION OF INDIA: ISSUES

Digital convergence is convergence of the following four industries into one, i.e., ITTCE – Information Technologies, Telecommunication, Consumer Electronics and Entertainment. It is the ability to view the same multimedia content from different types of devices, thanks to the digitisation of contents (movies, pictures, music, voice, text) and the development of its connection methods.

### *Use of Digital Convergence into Our Daily Life*

- Reading emails on our TV via a connected smartphone.

- Watching a streaming movie on the home theatre connected to the Internet.

*Communication Convergence Bill*

- Its core objective is to establish a new "converged" regulatory framework to promote and develop the communications sector (including broadcasting, telecommunications and "multimedia").
- The Convergence Bill proposes to repeal and replace existing sector laws, including:
  - The Indian Telegraph Act, 1885;
  - The Telecom Regulatory Authority of India Act, 1997.

*Objectives*

- To facilitate development of a national communication infrastructure, in order to provide a wide choice of services to consumers.
- To establish a regulatory framework that addresses the convergence of technologies, and defines the powers and roles of a signal regulatory and licensing licencing authority for broadcasting, telecommunications and multimedia.
- To establish a basis for codes and standards for broadcasting content.

## 9.12 E-GOVERNANCE: CONCEPT AND SIGNIFICANCE

Since 1990s, constant efforts are being made to improve the systems of public service delivery in order to reinvent governments worldwide. The recent innovations in ICT have facilitated the reinvention of governments and enabled them to serve the needs of a diverse society.

- Moreover, the information age has redefined the fundamentals and transformed the institutions and mechanisms of service delivery forever. The vision is the articulation of a desire that can transform the functionality of the government and the way it relates to its constituents.
- Electronic governance, as a concept, is popularly called e-governance. The vision majority of democracies of the world share is e-governance, as a way of life.
- India has been at the forefront of the IT revolution, thereby making its contribution to the public administration systems, as we would see later in this unit. As a matter of fact, the potential of ICTs, if harnessed properly, has a lot of opportunities, especially for social and economic growth of the developing world.
- As per Ministry of Information and Technology, the role of e-governance goes far beyond mere computerisation of stand-alone back-office operation. It leads to fundamental changes in government operations; and new set of responsibilities for the legislature, executive, judiciary and citizens.
- It is providing public access to information via the Internet by government departments and their agencies.

### 9.12.1 Objectives of e-Governance

- Better service delivery to citizens
- Ushering in transparency and accountability
- Empowering people through information
- Improve efficiency within Government, i.e. between centre-state or inter-states
- Improve interface with business and industry

### 9.12.2 Pillars of e-Governance

- People
- Process
- Technology
- Resources

### 9.12.3 Types of Interaction in e-Governance

- G2G, i.e. Government to Government
- G2C, i.e. Government to Citizen
- G2B, i.e. Government to Business
- G2E, i.e. Government to Employees

### 9.12.4 Benefits/Outcomes of e-Governance

- Enhanced transparency and accountability
- Expanded reach of Governance
- Improved public administration
- Enables environment for promoting economic development
- Improved service delivery in the form of better access to information and quality services to citizens

### 9.12.5 Many e-Governance Programmes

- **Bhoomi:** Bhoomi is a project jointly funded by the **Government of India** and the **Government of Karnataka** to digitise the paper land records and create a software mechanism to control changes to the land registry in Karnataka.
- **Khajane: Its G2G-based e-Governance Platform launched in Karnataka.** It has been implemented mainly to eliminate systemic deficiencies in the manual treasury system and for the efficient management of state finances.
- **e-district:** The Mission Mode Project aims at delivery of high volume, citizen-centric services at the district level such as the issue of birth/death certificate, income and caste certificates, old age and widow pension etc. It was launched by the **Department of Information Technology**.
- **MCA:** The project aims to provide electronic services to the companies registered under the Companies Act. Various online facilities offered include allocation and change of name, incorporation, online payment of registration charges, change in address of registered office, viewing of public records and other related services. The **Ministry of Corporate Affairs** launched it.
- **e-Seva:** All the services are delivered online to consumers/citizens by connecting them to the respective **government departments in Andhra Pradesh** and providing online information at the point of service delivery. The project has become very popular among the citizens especially for the payment of utility bills.
- **e-Courts:** It was launched by the **Department of Justice, Ministry of Law and Justice**. The Mission Mode Project (MMP) aims at utilising technology for improved provisioning of judicial services to citizens.
- **e-Office:** The Mission Mode Project aims at significantly improving the operational efficiency of the Government by transitioning to a "Less Paper work". **The Department of Administrative Reforms & Public Grievances** launched it.

Note: **Now e-Governance is considered under the 9 Pillars of Digital India.**

## 9.13 NATIONAL e-GOVERNANCE PLAN (NeGP)

- The Department of Electronics and Information Technology (DeitY) and Department of Administrative Reforms and Public Grievances (DARPG) formulated the National e-Governance Plan (NeGP).
- The NeGP, comprising 27 Mission Mode Projects (MMPs) and 10 components, was approved by Union Government on 18 May 2006.
- Mission Mode Projects: A Mission Mode Project (MMP) is an individual project within the National e-Governance Plan (NeGP 2.0) that focuses on one aspect of electronic governance, such as banking, land records or commercial taxes, etc. Within NeGP 2.0, "mission mode" implies that projects have clearly defined objectives, scopes, and implementation timelines and milestones, as well as measurable outcomes and service levels. NeGP 2.0 comprises of 44 MMPs, which are further classified as state, central or integrated projects.
- It aims at improving delivery of government services to citizens and businesses with the vision: "To make all Government services accessible to the common man in his locality through common service delivery outlets and ensure transparency, reliability and efficiency of such services at affordable costs, to realise the basic needs of a common man."

In order to promote e-Governance in a holistic manner, various policy initiatives and projects have been undertaken to develop core and support infrastructure.

The major core infrastructure components are **State Data Centres (SDCs), State Wide Area Networks (SWAN), Common Services Centres (CSCs) and middleware gateways, i.e. National e-Governance Service Delivery Gateway (NSDG), State e-Governance Service Delivery Gateway (SSDG), and Mobile e-Governance Service Delivery Gateway (MSDG).**

The important support components include Core policies and guidelines on Security, HR, Citizen Engagement, Social Media as well as Standards related to Metadata, Interoperability, Enterprise Architecture, Information Security, etc. New initiatives include a

framework for authentication, viz. e-Pramaan and G-I cloud, an initiative which will ensure benefits of cloud computing for e-Governance projects.

**STATE DATA CENTRES (SDCs)**

It is proposed to establish data centres in all the states/union territories to host state-level e-Governance applications/data via common and secure IT infrastructure. This will enable seamless delivery of Government-to-Government (G2G), Government-to-Citizen (G2C) and Government-to-Business (G2B) services, duly supported by State Wide Area Network (SWAN) and Common Service Centres (CSC), which are established at the village level.

**STATE-WIDE AREA NETWORKS (SWANs)**

SWANs act as a converged backbone network for data, voice and video communications throughout a state/union territory. It is expected to handle the information communication requirements of all the departments.

**COMMON SERVICES CENTRES (CSCs)**

The CSCs are ICT-enabled kiosks with broadband connectivity to enable various government, private and social services at the doorstep of citizens. The Government aims to create 1,00,000 CSCs across 600,000 rural and remote locations of India.

### 9.13.1 Meghraj (GI Cloud)

DeitY has initiated a project called 'Meghraj', with a view to harness the benefits of cloud technology. Another name for Meghraj is the GI Cloud Initiative (GI – Government of India). This project aims at creating the Government of India Cloud (GI Cloud) computing environment at the national level.

This initiative primarily focuses on evolving a strategy and implementing various components including governance mechanism, thereby ensuring proliferation of cloud in government. Meghraj's role will be a common receptacle of cloud-based infrastructure resources and applications available on demand. It will enable our government for the effective delivery of e-services.

**CLOUD COMPUTING**

- Cloud computing is a tool for enabling ubiquitous, convenient, on-demand network access to a various shared configurable computing resources (e.g., networks, services, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.
- Cloud computing is defined as the storing and accessing of data and programmes over the Internet, instead of a computer's hard drive. On top of this, cloud in the term of Cloud Computing refers to a set of hardware, storage, services, networks, and interfaces combining to deliver aspects of computing as a service.
- So, over and above sharing information, even the infrastructure can be shared on real-time basis on the Internet.

#### 9.13.1.1 Components of Government's Cloud Computing

- Five essential characteristics of cloud computing – on demand self-service, ubiquitous network access, metered use, elasticity and resource pooling.
- Three service models including infrastructure as a service, software as a service and platform as a service and four deployment models – public cloud, hybrid cloud, private cloud and community cloud.
- The initiative accelerates delivery of e-services provided by the government, thereby optimising ICT spending of the government.

#### 9.13.1.2 Advantages of GI Cloud

- Optimum utilisation of existing infrastructure.
- **Rapid Deployment and Reusability:** A software availed by any department in government of India can be made available to other departments with no additional costs.
- **Manageability and Maintainability:** A single point for maintenance of ICT infrastructure in India is provided by it.

- **Scalability:** Infrastructure of the government can be increased as a response to the demands from the citizens of India.
- Efficient service delivery.
- **Security:** A security framework for the entire GI Cloud will lead to less environmental complexity and less potential vulnerability.
- Increased user mobility.
- Reduced effort in managing technology.
- Ease of first-time IT solution deployment.
- Cost reduction.
- **Standardisation:** GI Cloud shall prescribe the standards around interoperability, integration, security, data security and portability, etc.

#### 9.13.1.3 Uses of Meghraj

Not only through Internet but also via mobile connectivity, the GI Cloud will provide services to government departments, citizens and business. Besides accelerating the delivery of e-services to citizens and businesses, the government's cloud-based service delivery platform will also support other objectives such as increased standardisation, interoperability and integration, etc.

#### 9.13.1.4 Main Issues of the GI Cloud Initiative

- Lack of common policies among states and centres will challenge application reuse.
- Individual technology stacks and a lack of infrastructure standardisation will limit success.
- Lack of a clear mandate or incentives will affect G-Cloud uptake.

### 9.13.2 e-Taal: Electronic Transactions Aggregation and Analysis Layer

e-Taal is a web portal developed by NIC (National Informatics Centre) for aggregation and analysis of e-transaction statistics of central and state level e-governance projects, which also includes MMPs. The transaction statistics is received from web-based applications periodically on near real-time basis and presents status on actual utilisation of various applications running at various locations.

It also assists with quick analysis of transaction counts in tabular form as well as graphical form to give quick view of the category and number of transactions done through e-governance projects. e-Taal provides visibility for the national/state level e-governance services.

### 9.13.3 UMANG (Unified Mobile Application)

UMANG is the acronym for Unified Mobile Application for New-age Governance, which is also popular with the name of mobile governance in India. After BHIM app, PM Modi launched UMANG app for government services.

This app is developed by National e-Governance Division (NeGD) and Ministry of Electronics and Information Technology (MeitY) and was launched in November 2017. It encourages people to opt for digital payment transactions in the country. UMANG app is a single-window platform with multiple applications of pan India e-government services like income-tax filing, making Aadhar, booking a gas cylinder, Passport Seva and provident fund queries, etc.

Here, people can access more than 100 services at the level of regional, state and central governments. Umang is a part of Digital India initiative to adopt a new-age governance policy. This application is also allowed through the web, SMS, or IVR (Interactive voice response).

**DND 2.0 AND DND 3.0**

**TRAI has now incorporated its Mobile App named as DND 2.0. DND (Do Not Disturb) Services App** facilitates smart phone users for registering their mobile number under DND and reporting spam messages or calls for avoiding Unsolicited Commercial Communication (UCC)/ Telemarketing Calls/SMS.

**TRAI DND 3.0 (Do Not Disturb)**

The new release (built ground up) has the following additional features:

- An intelligent spam detection engine (for SMS only) to assist the subscriber in reporting
- Crowdsourcing of data about offending messages and calls to speed up detection of unregistered telemarketers
- Updates about action taken on complaints within the App
- Easier interface and set up.

TRAI DND App is now also available on UMANG App (Government of India Initiative).

## 9.14 BHARAT INTERFACE FOR MONEY (BHIM) APP

***Bharat Interface for Money (BHIM)*** is a UPI-based payment interface, developed by ***National Payments Corporation of India (NPCI). It allows real time fund transfer. BHIM app was launched in December, 2016.***

The BHIM apps has three levels of authentication:

1. For one, the app binds with a device's ID and mobile number.
2. Second a user needs to sync whichever bank account (UPI or non-UPI enabled) in order to the conduct transaction.
3. Third, when a user sets up the app they are asked to create a pin which is needed to log into the app. The UPI pin, which a user creates with their bank account is needed to go through with the transaction.

### 9.14.1 What is UPI?

***Unified Payments Interface (UPI)*** is a system that powers multiple bank accounts into a single mobile application (of any participating bank), merging several banking features, seamless fund routing & and merchant payments into one hood. It also caters to the ***"Peer to Peer"*** collect request which can be scheduled and paid as per requirement and convenience. Each Bank provides ***its own UPI App for Android, Windows and iOS mobile platform(s).***

#### *Achievements of UPI*

- Digital transactions through UPI **recorded phenomenal growth during the pandemic year 2020–21** and **several countries have evinced interest** to learn from Indian experience so that they could replicate the model.
- The value of transactions made using the UPI **crossed USD100 billion in a month for the first time in October, 2021** according to data from the NPCI, further cementing its position as India's most popular digital payments system.
- **India's digital payments industry** is likely to grow from ₹2,153 trillion **at 27% Compounded Annual Growth Rate (CAGR)** to ₹7,092 trillion by 2025.

#### *Why UPI is outperforming e-wallets?*

- People are changing the way they transact, choosing bank-to-bank methods such as the Unified Payments Interface (UPI) over other instruments such as e-wallets. ***This is because UPI is completely interoperable and as such, it is unique in the world, where you have an interoperable system on the 'send' and 'receive' side.***
- The rapid growth of UPI is accompanied by a reasonably strong growth in the value of transactions done using e-wallets, but the latter's growth has not taken off much following the fillip it received in the aftermath of demonetisation in November 2016.

### 9.14.2 UPI – Benefits to the Ecosystem Participants

#### *Benefits for Banks*

1. Universal application for transaction.
2. Leveraging existing infrastructure.
3. Safer, secured and innovative.
4. Payment basis single/unique Identifier.
5. Enable seamless merchant transactions.

#### *Benefits for end Customers*

- Round the clock availability.
- Single application for accessing different bank accounts.
- Use of virtual ID is more secure, no credential sharing.
- Single click authentication.
- Raise complaint from mobile app directly.

#### *Benefits for Merchants*

- Seamless fund collection from customers – single identifiers.
- No risk of storing customer's virtual address like in Cards.
- Tap customers not having credit/debit cards.
- Suitable for e-Com & and m-Com transaction.
- Resolves the COD (Cash on demand) collection problem.

### 9.14.3 About NPCI

- NPCI is ***an umbrella organisation for operating retail payments and settlement systems in India.***
- It is ***an initiative of Reserve Bank of India (RBI) and Indian Banks' Association (IBA) under***

***the provisions of the Payment and Settlement Systems Act, 2007***, for creating a robust Payment and Settlement Infrastructure in India.

- It has been ***incorporated as a not for profit company***.
- In 2016 ***the shareholding was broad-based to 56 member banks to include more banks representing all sectors***.

**BHIM 2.0**

Government launched ***BHIM 2.0*** with new functionalities, additional language support.

**What is BHIM?**

- ***Bharat Interface for Money (BHIM) is a UPI-based payment interface.***
- Developed by ***National Payments Corporation of India (NPCI)***. Allows real-time fund transfer. ***Launched*** in December, 2016.

**What's new in BHIM 2.0?**

- Donation' gateway, increased transaction limits for high value transactions, linking multiple bank accounts, offers from merchants, option of applying in IPO, gifting money.
- It also supports three additional languages – Konkani, Bhojpuri and Haryanvi – over and above the existing 13.

**BHIM UPI GOES INTERNATIONAL**

- ***BHIM app*** has gone international with a pilot demo of ***BHIM UPI QR-based payments*** beginning at ***Singapore FinTech Festival 2019***.
- This QR code-based system would ***allow anyone with a BHIM app to scan the SGQR at NETS terminals for payments in Singapore.***
- The project is being ***jointly developed by NPCI and NETS of Singapore.*** It was targeted to go live by Feb 2020, but got delayed.

**After Singapore, Bhutan adopts India's BHIM-UPI**

- **Bhutan has become the first country to adopt India's Unified Payment Interface (UPI) standards for its quick response (QR) code. It is also the second country after Singapore to have BHIM-UPI acceptance at merchant locations.**
- **Bhutan will also become the only country to both issue and accept RuPay cards as well as accept BHIM-UPI.**

## 9.15 PRAGATI (PRO-ACTIVE GOVERNANCE AND TIMELY IMPLEMENTATION)

It is a multi-purpose and multi-modal governance platform launched on 25 March 2015. An unique integrating and interactive platform, PRAGATI is aimed to address common man's grievances, and at the same time, monitor and review important programmes and projects of the GOI and projects flagged by state governments.

It is an innovative project in e-governance and good governance and accountability with real-time presence and information exchange among the key stakeholders.

Key features of the PRAGATI application are:

1. The PMO, Union Government Secretaries, and State Chief Secretaries constitute PRAGATI application and hence it is a three-tier system.
2. Designed in-house by the Prime Minister's Office (PMO) team with the help of National Informatics Centre (NIC).
3. Three latest technologies, including digital data management, geo-spatial technology and video-conferencing, are used to connect under PRAGATI.
4. To interact with the Government of India Secretaries and Chief Secretaries, the Prime Minister will hold a monthly programme once in every month on the fourth Wednesday at 3:30 PM. This programme (to be known as PRAGATI Day) is held through video-conferencing, enabled by data and geo-informatics visuals.
5. Prime Minister can directly discuss the issues with the concerned Central and State officials with full information and latest visuals of the ground-level situation.
6. The system will work on strengthening and re-engineering the databases of Centralised Public Grievance Redress And Monitoring System (CPGRAMS), along with Project Monitoring Group (PMG) and the Ministry of Statistics and Programme Implementation.

## 9.16 AADHAAR

A revolutionary step in terms of digitalisation of proof of identity came in the form of Aadhaar. It is a 12-digit individual identification number issued by the Unique

Identification Authority of India (UIDAI), on behalf of the Government of India. This 12-digit number serves as a proof of identity and address, anywhere in India. Aadhaar letter can be received *via* India Post, in form of e-Aadhaar downloaded from UIDAI website, both being equally valid.

Irrespective of age or gender, one can enrol for Aadhaar, being a resident of India and satisfying the verification process laid down by UIDAI. Single enrolment is required and that is free of cost. Each Aadhaar number is unique to an individual with lifelong validity. In due course of time, it is expected that *via* Aadhaar number one can access services like banking, mobile phone connections and other government and non-government services.

*Basic Properties of Aadhaar*

1. Easily verifiable in an online, cost-effective way.
2. Unique and robust enough, thus eliminating the large number of duplicate and fake identities in government and private databases.
3. A random number generated, devoid of any classification, be it on basis of caste, creed, religion or geography.

Note: The UIDAI has brought in secure, digitally-signed QR Code on e-Aadhaar that will now contain photograph of the Aadhaar holder too, in addition to demographic details, to facilitate better offline verification of an individual. "The UIDAI (Unique Identification Authority of India) has recently replaced existing QR code on e-Aadhaar having resident's demographic details now with a secured digitally-signed QR Code, which contains demographics along with photograph of the Aadhaar holder".

## 9.17 DIGITAL LOCKER

The Government of India launched DigiLocker, which is a digital locker service, in February 2015 to provide a secure dedicated personal electronic space for storing documents like PAN card, passport, marksheets, degrees and certificates. It is linked to Aadhar number.

This locker maybe linked to a person's Aadhaar number. 10 megabytes of space is offered, which is further extended to 1-gigabyte space for all the documents, free of cost. It acts like a physical locker where the jewellery and documents can be stored, except the fact that it is digital, i.e., on website and will store digital information, in place of physical assets.

On 7 September 2016, Union Road Transport Minister, Nitin Gadkari initiated the integration of DigiLocker with the Driving License and Vehicle Registration system of the Ministry of Road Transport and Highways.

The Central Board of Secondary Education (CBSE) has issued mark sheets to class XII students in digital format along with hard copies for the students in their digital lockers from 2015.

It is one of the key initiatives under the Digital India Programme. **Mahaonline** Limited, the joint venture between Maharashtra government and Tata Consultancy Services (TCS) has developed and maintains this website.

Digital locker minimises the usage of physical documents, thereby enabling sharing of e-documents across agencies. It will reduce the administrative overhead of government departments and agencies created due to paper work. It promotes the concept of paperless governance.

The Government of India launched this service to provide a secure dedicated personal electronic space for storing the documents of resident Indian citizens. The useful websites to access these benefits are: *http digilocker.gov.in/ and https:// digitallocker.gov.in/*

Other objectives of digital locker include:

1. Digital empowerment of residents by providing them with Digital locker on the cloud.
2. Enable e-signing of documents and making them available electronically and online. Minimise the use of physical documents.
3. Ensure authenticity of the e-documents and thereby eliminating usage of fake documents.
4. Secure access to government-issued documents through a web portal and mobile application for residents.
5. Reduce administrative overhead of government departments and agencies and making it easy for the residents to receive services.
6. Anytime, anywhere access to the documents by the resident.
7. To support a well-structured standard document format via open and interoperable standards-based architecture that can support easy sharing of documents across departments and agencies.
8. Ensure privacy and authorised access to resident's data.

## 9.18 JAM TRINITY

JAM stands for three things – The Jan Dhan Yojana, the Aadhaar initiative of UIDAI and Mobile number. These

three things are often called the Trinity of reforms in India. The JAM Trinity holds the key to implement large-scale, technology-enabled, real-time direct benefit transfer (DBTS) to improve the economic condition of the India's poor. The first application of JAM was PAHAL scheme of transferring LPG subsidies directly to the account of BPL people. Though riddled with challenges of beneficiary identification, distributor-opposition and beneficiary financial inclusion, JAM trinity is expected to reduce leakages and provide more financial space to the government.

## 9.19 ONE NATION ONE FASTAG

***One Nation One FASTag scheme*** inaugurated by GoI. The government has already announced that ***FASTags will be mandatory for all vehicles at all National Highways from 1 December 2019.***

Finally, Union Road Transport and Highways Ministry has decided that all lanes in the fee plazas on National Highways shall be declared as 'FASTag lane of the fee plaza' from midnight of 15th/16th February 2021. One can continue to use your FASTag for 5 continuous years, without having to re-register it.

Any vehicle not fitted with FASTag will have to pay twice the fee for the category of the vehicle they are driving at electronic toll plazas across India. ANPR-Automatic Number Plate Reader is expected to replace Toll Plaza and FASTag on Highway.

### *Features of the Scheme – One Nation One FASTag*

- The scheme will be implemented from December 1, 2019, and can be availed upon activation by new cars having Radio Frequency Identification (RFID) tags on national and state highways throughout the country.
- The plan aims to integrate the collection of toll digitally and ensure seamless mobility of vehicles across India.
- The payment method is a part of ***the National Electronic Toll Collection (NETC) programme.*** The ***National Payments Corporation of India (NPCI)*** collects the payments.

### *What is 'FASTag'? How they operate?*

- Stickers affixed to the windscreen of vehicles.
- Use RFID technology to enable digital, con-tactless payment of tolls without having to stop at toll gates.
- The tags are linked to bank accounts and other payment methods.
- Sensors are placed on toll barriers, and the barriers open for vehicles having valid FASTags.
- A FASTag is valid for five years and needs to be recharged only as per requirement.

### *Why do we need this scheme?*

- According to the National Highways Authority of India (NHAI), these devices will make passing

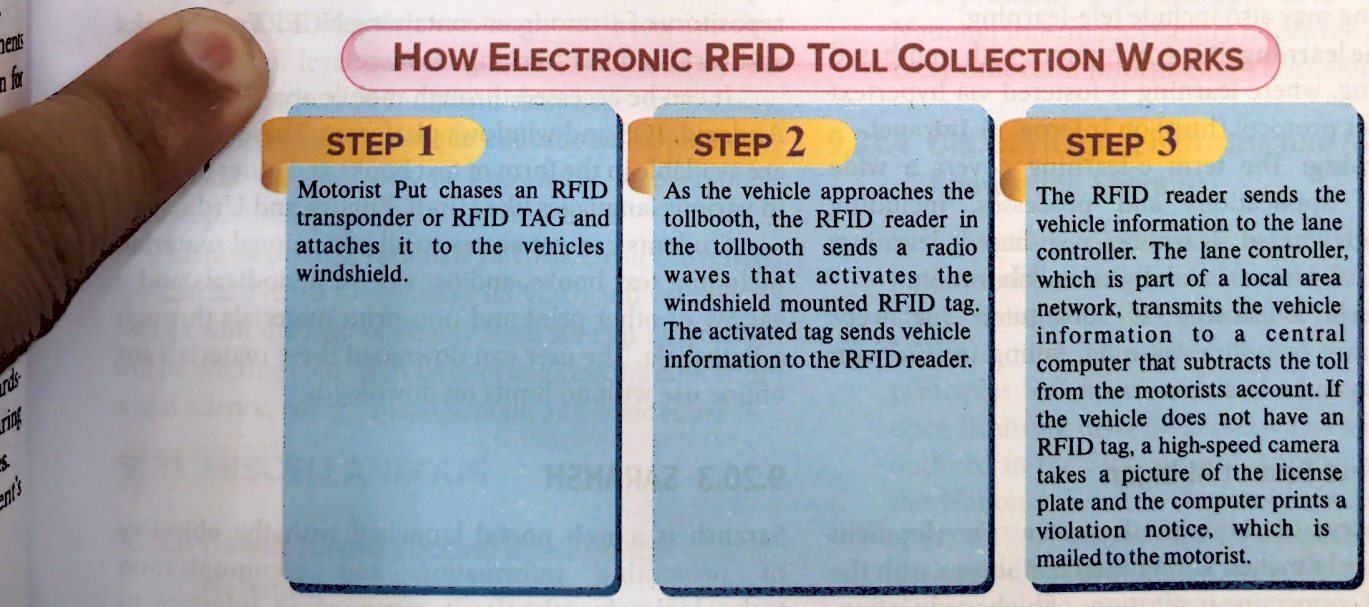

HOW ELECTRONIC RFID TOLL COLLECTION WORKS
STEP 1
Motorist Put chases an RFID transponder or RFID TAG and attaches it to the vehicles windshield.
STEP 2
As the vehicle approaches the tollbooth, the RFID reader in the tollbooth sends a radio waves that activates the windshield mounted RFID tag. The activated tag sends vehicle information to the RFID reader.
STEP 3
The RFID reader sends the vehicle information to the lane controller. The lane controller, which is part of a local area network, transmits the vehicle information to a central computer that subtracts the toll from the motorists account. If the vehicle does not have an RFID tag, a high-speed camera takes a picture of the license plate and the computer prints a violation notice, which is mailed to the motorist.

**Figure 9.1**
Working mechanism of FASTag

through tolls considerably smoother since drivers will no longer have to carry cash or stop to make a transaction.

- Cameras at toll booths will take photos of passengers in a vehicle, which will be useful for the Ministry of Home Affairs as there will be a record of a vehicle's movement.

## 9.20 e-LEARNING (EDUCATION AND INTERNET TECHNOLOGY)

The Internet and its World Wide Web have captured the imagination and interests of millions around the world, leading to use of terms like web-based learning, online learning, etc. The interests in the educational use of the web has been driven by higher demands for education and training, shift in the societal economy from labour-intensive to knowledge-intensive work, and need for earning while learning. As the terminology in e-learning needs further standardisation, many terms were used inter-changeably.

1. **Web-based instruction:** It is a hypermedia-based instructional programme which utilised the attributes and resources of the World Wide Web to create a meaningful learning environment where learning is fostered and supported.
2. **Virtual learning:** The educational process of learning over the Internet without having face-to-face contact is known as virtual learning. Virtual learning may also include tele-learning.
3. **Online learning:** It is synonymous with web-based learning, where learning is fostered via hypertext transfer protocol (http) on Internet or Intranet.
4. **e-learning:** The term e-learning covers a wide set of applications and processes, including computer-based learning, web-based learning, virtual classrooms and digital collaboration.

The term e-learning is substituted for web-based learning or online learning, falling in line with e-commerce and e-business.

### 9.20.1 Unnat Bharat Abhiyan

The Ministry of Human Resource Development (MHRD) has launched Unnat Bharat Abhiyan with the objective of connecting institutions of higher education, including Indian Institutes of Technology (IITs), National Institutes of Technology (NITs) and Indian Institutes of Science Education and Research (IISERs), etc., with local communities to address the development challenges through appropriate technologies. Unnat Bharat Abhiyan was launched in 2014.

There are two main objectives of Unnat Bharat Abhiyan:

1. Building institutional capacity in institutes of higher education in research and training relevant to the needs of rural India.
2. Providing rural India with professional resource support from institutes of higher education, especially those that have acquired academic excellence in the field of science, engineering and technology and management.

Under this programme, 132 villages have been identified for intervention by the following 16 institutes of higher education: 14 IITs (Mumbai, Bhubaneshwar, Delhi, Guwahati, Hyderabad, Indore, Jodhpur, Kanpur, Kharagpur, Madras, Mandi, Patna, Roorkee, Ropar), IISER Bhopal and MNIT Jaipur.

### 9.20.2 e-Pathshala

e-Pathsala is a web portal hosting educational resources for students, teachers, parents, researchers and educators. As a part of the Digital India campaign, the MHRD (GoI) and NCERT (National Council of Educational Research and Training) jointly launched 'e-pathshala' in November 2015, as a single point repository of e-resources containing NCERT text books and various other learning resources.

It can be accessed through mobile app interface on Android, IOS and windows platforms. These resources are available in the form of text books and other e-books in various languages like Hindi, English and Urdu.

Students can get access to all educational material, including text books, audios, videos, periodicals and a variety of other print and non-print materials through e-Pathshala. The user can download these materials for offline use with no limits on downloads.

### 9.20.3 SARANSH

Saransh is a **web portal** launched with the objective of promoting information and communication technologies in schools. It serves as an interface to enhance communication between schools and parents as a self-review tool. This web portal was launched by

the Human Resource and Development Minister for Central Board of Secondary Education (CBSE)-affiliated schools, in November 2015, to promote Communication and Information technology. **This portal will help to evaluate the strengths and weaknesses of children, which will help with the children's future.**

It is a progress of Digital India campaign and will bring transparency to the educational system. It intends to provide e-books of all standards and subjects, thereby encouraging sustainable development. It is a kind of one-on-one interaction platform between teachers and parents. It directly shares information about performance and attendance of students to parents. This portal will save three preceding years' data of all schools. Hence, a comparative year-on-year performance can be checked.

### 9.20.4 Indian MOOCs: "SWAYAM"

SWAYAM or **Study Webs of Active-Learning for Young Aspiring Minds** programme is brought forward by the MHRD, Government of India in 2016, as a Massive Open Online Courses (MOOCs). Under this programme, various eminent Professors of IITs, IIMs and Central University, etc., will offer online educational courses.

It is an instrument for self-actualisation of learning offered free of cost. Here, learners can choose from hundreds of courses that are taught at the university/college/school level and these shall be offered by the best of the teachers in India and elsewhere. In this way, SWAYAM provides a unique educational opportunity to expand the horizons of knowledge at everyone's doorstep.

In the beginning, various IITs, IIMs, Delhi University, Jawaharlal Nehru University, IGNOU, individually as well as with the help of faculty from foreign universities will be offering courses in areas of engineering education, social science, energy, management, and basic sciences.

## 9.21 MISCELLANEOUS

### 9.21.1 CoWIN (Covid Vaccine Intelligence Network)

- It is an Indian government web portal for COVID-19 vaccination registration.
- It is owned and operated by India's Ministry of Health and Family Welfare.
- It displays booking slots of COVID-19 vaccine available in the nearby areas and can be booked on the website.

### 9.21.2 MANAS App

- MANAS App is a well-being App that stands for **Mental Health and Normalcy Augmentation System.**
- It is endorsed as a national programme by the Prime Minister's Science, Technology, and Innovation Advisory Council (PM-STIAC).
- MANAS is a comprehensive, scalable, and national digital wellbeing platform and an app developed to augment the mental well-being of Indian citizens.
- MANAS App integrates the health and wellness efforts of various government ministries, scientifically validated indigenous tools with gamified interfaces developed/researched by various national bodies and research institutions.

### 9.21.3 Aarogya Setu

- It is an Indian COVID–19 "contact tracing, syndromic mapping and self-assessment" digital service.
- It is primarily a mobile app, developed by the National Informatics Centre under the Ministry of Electronics and Information Technology (MeitY).

### 9.21.4 DIKSHA (Digital Infrastructure for Knowledge Sharing)

- It is a national platform for school education, an initiative of National Council for Education Research and Training (NCERT), Ministry of Education.
- DIKSHA was developed based on the core principles of open architecture, open access, open licensing diversity, choice and autonomy as outlined in the Strategy and Approach Paper for the National Teacher Platform released in May, 2017. DIKSHA itself was launched by the Hon' Vice President of India on Sept 5$^{th}$, 2017 and has since been adopted by 35 states/UTs across as well as CBSE and NCERT and by crores of learners and teachers.

### 9.21.5 Digi Yatra App

- The Airports Authority of India launched the Digi-Yatri service that will provide contactless entry to passengers at airports by using facial recognition technology.
- Digi Yatra – **Digital processing of passengers at the airports.** Passengers will be automatically processed based on facial recognition system at check points like, **Entry point check, Entry into Security Check, Aircraft Boarding.** Additionally, this will also facilitate self-Bag Drop and Check-in, using **facial recognition** to identify pax and data recall. Digi Yatra will facilitate paperless travel and avoid identity check at multiple points.
- Passenger can create Digi Yatra ID in a central system by providing the following: 1. Name, 2. Email ID, 3. Mobile Number, 4. Details of Identity (Voter Id, Driving Licence, Aadhar etc.). On submission the Digi Yatra Id will be created. Pax can quote this number while booking the ticket. Pax data including Digi Yatra ID will be passed on to departure airport by the airlines.

## QUESTIONS AND ANSWERS

## 10.1 INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT)

The technologies, which enable society to create, collect, consolidate, communicate, manage and process information in multimedia and various digital formats, render various purposes *via* the application of telecommunication techniques.

UNESCO defines ICT as **'the scientific, technological and engineering disciplines and the management techniques used to handle, transmit information with men and machines'.**

*Impact of ICT on Society*

Developments in ICT have greatly enabled exchange of information anytime, anywhere in the digital format lent by computers. It has enormous impact in everyday life, such as the use of email and cellular phones at home and the workplace and linked to all facets of society: business, education, communication, scientific exploration, knowledge management, etc.

## 10.2 EVOLUTION OF TELECOMMUNICATIONS

Communication is a mode of voice system, which is two-way whereas information is a data trafficking system which is one way. **India stands at the second position in terms of both telecommunication and Internet users in the world.** Now, both voice and Internet facilities have been merged together with the help of smartphones. Worldwide, two types of transmission mediums are used– **guided media** such as copper wire and fibre optics and **unguided media** such as electromagnetic waves (radiowaves, microwaves, LASER, etc.) through the air.

### 10.2.1 Wire Pairs

#### 10.2.1.1 Coaxial Cable

- A coaxial cable consists of a stiff copper wire as the core surrounded by an insulating material. Its application is for distance transmission. Additional advantage includes giving a good combination of high bandwidth, without distortion or loss of signal and excellent noise immunity.
- Earlier, they were used widely in telephone systems but are now replaced by fibre optics, on long-distance transmission.
- The coaxial cables that are used in analogue transmission are television cables, also termed as broadband coaxial cable.

#### 10.2.1.2 Optical Fibres

- In fibre optics, the semiconductor laser transmits data at speed of light in the form of light along hair-like thin fibres of glass, without any considerable intensity loss over very long distances. Hence, it is a potential, cost-effective alternative for the future.
- The three components of this transmission include the light source, the transmission medium and detector. Conventionally, a pulse of light indicates one bit and the absence of light indicates a zero bit. The transmission medium is an ultra-thin fibre of glass. When light falls on it, the detector generates an electrical pulse.
- There is a converter, which converts electrical signals into waves of light at the source end. These waves are transmitted over the fibre. With the help of photoelectric diodes, one more converter located near to sink changes the waves back to electrical signals. These electrical signals are then amplified and sent to the receiver.

Note: Photoelectric diode is a semiconductor device that converts light into current.

- They may be used to communicate either analogue or digital signals.
- The electromagnetic interference does not affect fibre optics transmission, thus reducing noise and distortion.
- They are most commonly used for end-to-end, one-way communication links because it is extremely difficult and expensive to tap a fibre optic cable at various points. This feature adds security against unauthorised tampering of information.

*Fibre Optics and Its Applications*

- The use of Internet, e-commerce, computer networks, multimedia, voice, data and video, has been growing faster and thus, the need for a transmission medium with high bandwidth capabilities is necessary. Fibre optics, with its

comparatively infinite bandwidth, has proven to be the solution.

- Optical fibre is also used extensively for transmission of data signals. Due to its inherent security system, it has encouraged application in large corporations, banks, universities, etc. Cable television or community antenna television (CATV) companies also find fibre useful for video services.
- These installations are easy and simple due to large bandwidth, relatively smaller diameter and lightweight of optical fibre. Additionally, fibre optic solution are cheaper than copper.
- High-quality signal can be transmitted using optical fibre for longer distances.
- The dielectric nature of optical fibre makes it impossible to remotely detect the signal being transmitted within the cable. This feature is quite beneficial to banks, government bodies and others with major security concern. For difference between Copper Wire and Optical Fibre, refer to **Table 10.1**.

**1 Comparison between Copper Wire and Optical Fibre**

| ers | Copper Wire | Optical Fibre |
|---|---|---|
| Made-up of | Copper | Silicon, Silicon oxide, etc. |
| Rusting | Yes | No |
| Life | Less | More |
| Weight | More | Less |
| Connection through single wire | Provides limited connection | Provides massive connection |
| Heat resistance | Low | High (up to 400°C, it does not melt) |
| Preferred by Defence | No | Yes |
| Bandwidth | Low | High |
| | Narrowband – Dial-up connection | Broadband – DSL, ADSL, Cable modem |
| Repeaters used | At less distance | More distance (minimum at 80 kilometres) |
| Quality | Average | Good |

### 10.2.1.3 Mode of Internet Connection through Landline/Basic Phone/through Wire

(a) **Dial-up:** Dial-up Internet access is a form of Internet access that uses the facilities of the Public Switched Telephone Network (PSTN) to establish a connection to an Internet Service Provider (ISP) by dialling a telephone number on a conventional telephone line. Both phone call and dial-up connections do not work at the same time. During call, Internet connection is disabled.

(b) **Digital Subscriber Line (DSL):** Digital subscriber line (DSL) is a broadband digital transmission service offered on ordinary telephone lines. DSL works within the frequencies that the telephone does not. The telephone and DSL modem can work at the same time, enabling the use of Internet while making phone calls. There are two main types of DSL technologies:

1. ***Symmetrical DSL:*** The bandwidth for upload and download speeds is equal.
2. ***Asymmetrical DSL (ADSL):*** The most popular type of DSL connection. Most people upload less information but download more. Thus, an asymmetrical connection has more downstream bandwidth and less upstream bandwidth.

#### Pros and Cons of DSL

***Pros***

- DSL is widely available, since it is built on existing phone lines. The cost is lesser than satellite or broadband Internet connections.

Note: DSL – Digital Subscriber Line, ADSL – Asymmetric Digital Subscriber Line.

- With DSL, each subscriber has a dedicated circuit, like separate phone services. Several subscribers online at once do not put a heavier demand on DSL lines. With cable Internet, neighbouring subscribers share a cable, so the connection can be slow during peak Internet usage times.

***Cons***

- They are faster but usually cost more.
- DSL connection is distance-sensitive, means the closer (to the central office), the better. When farther, the speed is reduced. DSL Internet is available wherever there is an existing telephone

network, and it offers a reliable and affordable connection.

### 10.2.2 Wireless Transmission

- Wireless is preferable for those areas where fibre running is difficult due to terrain constraints (mountains, jungles, swamps, etc.). It is noteworthy that modern wireless digital communication began in the Hawaiian Islands, where large chunks of Pacific Ocean separated the users and the telephone system was inadequate.
- Electromagnetic spectrum is the means of wireless transmission.

*Electromagnetic Spectrum*

- Electrons create electromagnetic waves capable of propagating through free space (even in a vacuum). These are invisible waves. James Clerk Maxwell first predicted these rays.
- The number of oscillations (a regular periodic variation about a mean position) per second of an electromagnetic wave is called its frequency (f) and the standard unit of measuring frequency is hertz (Hz). The wavelength denotes the distance between two consecutive maxima (the largest intensity) or minima (lowest intensity). It is denoted by Greek letter Λ (lambda).
- The electromagnetic waves can broadcast efficiently by attaching an antenna (an electrical device that sends or receives radio signals) of appropriate size to an electrical circuit and received by a receiver some distance away. All wireless communication work on this principle.
- In vacuum, all electromagnetic waves travel at the same speed, i.e. the speed of light, irrespective of their frequency.
- The electromagnetic spectrum consists of **radio, microwave, infrared** and **visible light**. They can all be used for transmitting information by modulating the amplitude, frequency or phase of the waves.
- Though ultraviolet light, x-rays and gamma rays would be better due to their higher frequencies, they are hard to modulate and do not propagate well through buildings and their harmful nature makes them of no good use for information transmission.

*Steps Taken by Government*

- **EMF emissions from mobile towers (they are non-ionising radio frequencies and not dangerous)**: Electromagnetic Field (EMF) emissions norms from mobile towers in India are already ten times more stringent (even lower) than the safe limits recommended by the WHO.
- **Monitoring of EMF emissions:** Telecom Service Providers (TSPs) are to adhere to the prescribed norms including the submission of a **self-certificate** before the commercial start of the Base Transceiver Station (BTS) site.
- **EMF audit** by the field units of the Department of Telecommunications (DoT).
- Penalty and shut down of services if found non-compliant.

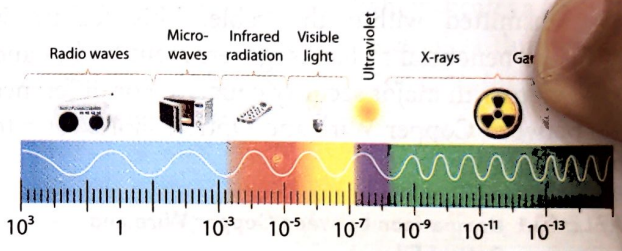



**Figure 10.1**
Types of Electromagnetic Radiation

#### 10.2.2.1 Microwave Transmission

- **Above 100-megahertz frequency**, microwave transmission is used. They travel in a **straight line (directional waves)** and can therefore, be **narrowly focussed**. A fairly strong signal is achieved by concentrating all the energy into a small beam, using a parabolic antenna.
- Microwave is relatively inexpensive and can be used for long distance transmission.
- It is widely used for long-distance telephone communication, cellular telephones, television distribution, etc.

#### 10.2.2.2 Radio Transmission

- Radio waves are widely used for communication, both indoors and outdoors, as they be generated easily and can travel long distances and penetrate buildings easily.

- Radio waves also are **omnidirectional,** that is they can travel in all directions from the source.
- At low frequencies, radio waves pass through obstacles well, but the power decreases. At high frequencies, radio waves tend to travel in straight lines and bounce off obstacles.
- They are also absorbed by rain. They are subject to interference from motors and other electrical equipment at all frequencies.

#### 10.2.2.3 Infrared and Millimetre Wave

- For short-range communication, infrared and millimetre waves are widely used. Examples include: The **remote controls** used on televisions, VCRs and stereos.
  They are relatively **directional**, cheap and easy to build, but a major drawback is that they do not pass through solid objects. Even this drawback is advantageous in the sense that an infrared system in one room of a building will not interfere with a similar system in adjacent rooms separated by solid walls.
  Infrared waves are mostly used in indoor wireless LANs (Local Area Network) and not in outdoor applications. The computers and offices in a building can be equipped with infrared transmitters and receivers.
- Security of infrared systems against eaves-dropping is better than that of radio system. Therefore, no government licence is needed to operate an infrared system, in contrast to radio systems, which must be licenced.

#### 10.2.2.4 Light Wave Transmission

- A more modern application is to connect the LANs in two buildings *via* lasers mounted on their rooftops. Since optical signalling using lasers is inherently unidirectional, each building needs its own laser and its own photo detector.
- This transmission offers very high bandwidth at very low cost as is relatively easy to install and unlike microwaves, does not require a licence.
- Laser beams cannot penetrate rain or thick fog, but they normally work well on sunny days.
- Heat from the sun during the daytime causes convection currents to rise up from the roof of the building. This turbulent air rivets the beam and resists it to reach the detector.

### 10.2.3 Analogue versus Digital Communications

- Based on communications signals, there are two types of communication systems – analogue (analogue signals) and digital communication systems (digital signals).
- In analogue signal, the signal varies continuously with respect to the data. In a digital signal, the data is encoded as discrete set of values (for example, ones and zeros).
- At the time of signal dissemination and reception, the data enclosed in analogue signals is unavoidably degraded by unwanted physical noise. Normally, the communication system noise can be articulated as addition or subtraction to the desirable signal in an entirely casual way, i.e. called as 'additive noise'. The noise, which is not being additive noise, is even more difficult in describing or analysing, hence, such noises will be lost here.
- However, until the disturbance in additive noise surpasses a definite threshold, the digit signals data will remain intact. Since the digital signals resist noise, it accounts as a key advantage of them over analogue signals.

### 10.2.4 Modem

- A special device termed as Modem undertakes the process of **modulation (converting of digital data into analogue)** and **demodulation (converting analogue data to digital).**
- During the usage of analogue facility for the communication of data between two digital devices (say a terminal and a computer), there is requirement of two modems, each near to the digital devices.
- The digital signal produced at the terminal is transformed into analogue by the modulator and the analogue signal being transmitted through telephone line into digital form by the demodulator of the modem respectively located near to computer.
- The digital data being processed by the computer are modulated to analogue form and returned to

terminal through the telephone line where the analogue signals are demodulated into digital for terminal display.

- Modems are used for:
  1. Allowing high transmission speed on an analogue line.
  2. Reducing the noise and distortion effects.
- A few modems consist of microprocessors and further allowing them for operating and functioning under a large number of different conditions and are termed as smart modems.
- Modems are generally provided by network operators (Department of Telecommunication of India) or by vendors who are not necessarily the manufacturers of computer systems. Hence, there is a need to standardise the interface between the modem and the computer equipment.
- Different types of modems are used, such as:
  (i) **Telephone modem:** Means of connecting to the Internet from home, via telephone.
  (ii) **DSL (Digital Subscriber Line) modem:** Used for high-speed data transmission.
  (iii) **Cable modem:** Offer high-speed Internet access over TV cables.

**Cable Modems** offer high-speed Internet access over TV cables. Theoretically, they offer speeds from 3 to 30 megabits per second, but in the real world, actual speed ranges from 400 to 1440 kilobits per second. It is used in TV technology.

### 10.2.5 Modulation

- To convey information, the signal is shaped through a process known as modulation/keying. **'Keying'** is a phenomena of representing digital message in the digital form as an analogue waveform with the help of modulation. There are different types of keying, such as phase-shift, frequency-shift, and amplitude-shift keying, based on the changes brought in. **Modulation to the carrier wave is the process of changing amplitude or frequency or phase of a carrier wave.** There are three basic types of modulation: (i) Phase-shift modulation, (ii) Frequency modulation (iii) Amplitude modulation.
  (i) Phase-shift Modulation:
    - The modulation, where the phase of the carrier wave is varied by an amount proportional to the phase of modulating signal, with no change in amplitude of the carrier.
    - For example, the 'Bluetooth' system, makes use of phase-shift keying for exchanging information amid various devices.
  (ii) Frequency-shift Modulation:
    - The change in frequency of carrier wave in accordance with the intensity of the signal is termed as frequency modulation with no change in the amplitude of the wave.
    - These are used for FM Channels, those work in a small area (like a district or city) and Radio broadcasting, Telemetry, Radar, Medical application (EEG), Seismic prospecting, etc.
  (iii) Amplitude-shift Modulation:
    - Practically, all the natural and man-made noises consist of electrical amplitude disturbances. Hence, it becomes difficult for the receiver to distinguish between noise and desired signal. Therefore, reception is noisy.
    - This is used in high-capacity digital radio communication systems at the big level, like All India Radio.

Note: In antenna-based television transmission, frequency modulation served for sound signal and amplitude modulation was used for picture signal.

- *Modulation is used for transmitting low-frequency analogue signals data to higher frequencies. These being a valuable feature, as the low-frequency analogue signals are not being transmitted over free space effectively.* Therefore, prior to transmission, the low-frequency analogue data must be impressed into a higher-frequency signal, which is termed as the **'carrier wave'**. There are several different modulation programmes for this purpose and out of these, the most basic is amplitude modulation (AM) and the other one is frequency modulation (FM).

## 10.3 MULTIPLE ACCESS/MULTIPLEXING

- **Multiplexing allows multiple mobile users to share a finite amount of radio spectrum simultaneously.** The sharing of spectrum should

achieve high capacity by simultaneously allocating the available bandwidth to multiple users. So, multiple accesses enables multiple signals to occupy a single communication channel.

- For higher quality of communications, severe degradation in the performance of the system must be avoided.
- Any information, i.e. voice/data in this case can be sent to another party only by the use of communication channel.
- For efficient use, the communication channel is allotted to the users in multiple ways, which is termed as Multiplexing.
- Types of Multiplexing:
  (a) Code Division Multiple Access (CDMA)
  (b) Frequency Division Multiple Access (FDMA)
  (c) Time-Division Multiple Access (TDMA)

### Frequency Division Multiple Access (FDMA)

FDMA is a technology where the total bandwidth available to the system is divided into frequencies. This division is done between two non-overlapping frequencies that are then assigned to each communicating pair (2 phones). **It is used mainly for analogue transmission.** In this technology, power consumption was very high. FDMA is considered as first-generation mobile phone technology.

### 10.3.2 Time Division Multiple Access (TDMA)

The division of calls happens on time basis, in TDMA. The calls are digitised initially, before combining conversations into a unified digital stream on a single radio channel. Each cellular channel is divided into three time slots under a single frequency, so three different users use one frequency at the same time. In TDMA technology, users transmit in rapid succession, each using their own time slot, thus allowing multiple stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity.

### 10.3.3 Code Division Multiple Access (CDMA)

Unlike FDMA, CDMA separates calls by code. Every bit of a conversation is tagged with a specific and unique code. A unique code is allocated to that particular conversation and later, this data is split into small parts and is tagged with the unique code given to the conversation of which they are part of. This tagged data in small pieces is sent over a number of the discrete frequencies available for use at any time in the specified range. In the end, the system then reassembles the conversation from the coded bits and delivers. It is similar to recollecting our luggage after a flight journey by matching the codes on the bag.

Note: TDMA and CDMA are second-generation mobile phone technologies.

### 10.3.4 A Comparative Study of GSM (Global System of Mobile Communication) and CDMA (Code Division Multiple Access)

Both GSM and CDMA technologies have various differences (**Table 10.2**).

#### 10.3.4.1 GSM – Global System of Mobile Communication (The Euro-Asian Alternative)

CDMA was introduced in Hong Kong in 1995. Further, Time Division Multiple Access (TDMA) technology introduced in Europe to support the first available digital technology. **GSM is one of the variants of TDMA technology**.

GSM is a 'cellular' technology, where the entire coverage area is divided into various hexagonal-shaped cells (hence the popular name 'cell phones'). Every cell has a corresponding network tower, which serves the mobile phones in that cellular area. For instance: imagine a honeycomb on a tree in a hexagonal-shaped garden. The garden has many flowers. The honeybees collect the nectar from many flowers, and deposit it in the honeycomb. Similarly, our mobile phones are like the flowers, the network tower is like honeycomb and bees are like the signals.

#### 10.3.4.2 CDMA – Code Division Multiple Access (US-Based Technology)

**CDMA's World War II Foundations:** CDMA, though had its roots in pre-World War II America, if put into an historical context, **it is a now patented technology that only became commercially available in mid-1990s.**

**TABLE 10.2** Comparative study of CDMA and GSM

| S. No. | Parameter | CDMA | GSM |
|---|---|---|---|
| 1. | Technology | Code Division Multiple Access | Global System for Mobile Communication |
| 2. | Storage Type | Internal Memory (Pre-programmed handset) | SIM (Subscriber identity module) card |
| 3. | Global Market Share | Approx. 20% | Approx. 80% |
| 4. | Dominance | In the US | Worldwide except the US |
| 5. | Network | There is one physical channel | Every cell has a corresponding and a special code for every network tower, which serves the device in the coverage network mobile phones in that cellular. Using this code, the signal of area, the device is multiplexed, and the same physical channel is used to send the signal |
| 6. | International Roaming Facility | Less accessible | More accessible |
| 7. | Frequency Band | Single frequency band (850 MHz) | Multiple frequency bands (850/900/1800/1900 MHz) |
| 8. | Network Service | Handset specific | SIM specific. User has the option to select handset of his choice or automatic mode |
| 9. | Echoes, Call Drop, Cross connection, Voice Quality | Good | Inferior |
| 10. | Cellular Communications Security | Very high so Defence prefers use of CDMA technology | Inferior |
| 11. | Size of Phone | Generally smaller | Generally larger |
| 12. | In Standby Mode | Power consumption less | Power consumption high |
| 13. | In Active Mode | Power consumption high | Power consumption low |

As the name suggests (Code Division Multiple Access), there are **multiple devices using the same spread spectrum** (hence, multiple access). Under CDMA, there is one physical channel and a special code for every device in the coverage network. The signal of the device is multiplexed and the same physical channel is used to send the signal (this codes may or may not change), by using this code. For instance, Assume a street with many buses, the bus will have many commuters and they will have to buy the tickets to travel on the bus. In CDMA, your mobile phone is like the commuter, your codes act as the tickets, the bus is a multiplexed carrier signal and the street is the spread spectrum.

**CDMA, incorporating spread-spectrum, works by digitising multiple conversations, attaching a code known only to the sender and receiver.**

This makes the communication more secure and hence the military loved CDMA, because coded signals with trillions of possible combinations resulted in extremely secure transmissions. **CDMA was launched commercially in Hong Kong in 1995.**

## 10.4 IONOSPHERE AND ITS IMPORTANCE IN WIRELESS COMMUNICATION

- Our mobile phone use becomes possible due to the presence of ionosphere in atmosphere.
- The air is dense in the part closer to the surface of Earth and moving up, it gets thinner. The air molecules get ionised producing positively charged ions and free electrons by the radiant energy of the Sun, especially the ultraviolet radiation. A free electron may recombine with a nearby ion, forming a neutral atom, which in turn may be ionised once again. Thus, a continuous process of ionisation and recombination takes place in the atmosphere at ionosphere.
- As a result, the ionosphere region is formed between 50 and 500 km of altitude. Within the

ionosphere, there are regions of concentration of electrons, and these may be considered as sub-layers within the ionosphere.

- Four such layers are present in the daytime, i.e. D layer, E layer, F1 layer and F2 layer (**Figure 10.2**) respectively. At night-time, the absence of ultraviolet radiation and the high recombination rate in the dense lower atmosphere makes the D layer disappear.

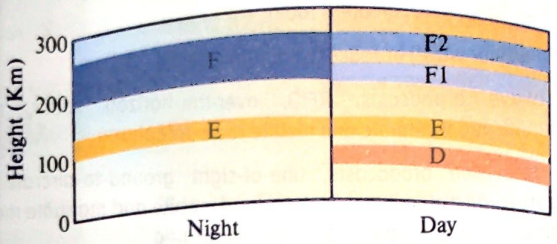



**Figure 10.2**
Ionosphere in day and night

- The height of the ionosphere layers are not constant but vary both daily and seasonally, as the intensity of Sun's radiation fluctuates. At sunset, the F1 layer rises, merging with the next higher F2 layer and forming a common F layer. Thus, there are only two layers present in the night, i.e. E layer and F layer.
- The condition of the ionosphere being dependent upon solar radiation undergoes change during the course of the day, over different seasons of the year and also over different years. Its condition is also affected by the sun spot cycle and solar flares.
- The layers of the ionosphere maybe considered as mirrors or partial mirrors depending on the amount of ionisation present. Thus, the transmitted waves striking on ionosphere layer may be refracted back to the earth and received after one refraction. This is called **'single hop transmission'**.

**Refraction:** The change in direction of light when it passes from one medium to another obliquely is called refraction of light or the bending of light when it goes from one medium to another obliquely is called refraction of light. Two mediums involved are dense medium (more density) and rarer medium (less density).

**Reflection:** The process of sending back the light rays, which falls on the surface of an object is called reflection of light. Only one medium is involved here.

- In some cases, the waves may be refracted back from the Earth to the ionosphere and the process of refraction and reflection is repeated several times before reaching the distant receiver. This is called **'multi hop transmission'.**
- Long-distance transmission or radio communication becomes possible due to ionosphere.

## 10.5 CONVENTIONAL PHONE VERSUS SATELLITE PHONE

- Conventional phone works from tower to tower but satellite phones directly connect through satellite to the Earth-bound network.
- Satellite phone works everywhere even in the absence of tower range like: **Himalayas, Sahara desert, polar region, ship, aircraft,** etc.
- Conventional phones work due to the presence of ionosphere because it reflects electromagnetic waves and calls become possible from tower to tower. But in the case of satellite phone signal will go to satellite with the help of some carrier waves.
- Satellite Phone Network Provider: **Globalstar, Thurya, Iridium.**
- Limitations with satellite phone – Call delay and call minutes are costly.

## 10.6 RADIOSPECTRUM

It is a part of electromagnetic spectrum having frequency in the range of 3–3000 GHz (3 THz). In this frequency range, electromagnetic waves are called radiowaves, and those are highly used in telecommunication. **International Telecommunication Union (ITU) divides this radio spectrum into 12 bands with various uses.** Those are given in **Table 10.3.**

## 10.7 TYPES OF TRANSPONDERS, THEIR FREQUENCIES AND USES

A satellite receives, modulates, amplifies and re-transmits an uplinked signal with the help of transponders. **Transponders are part of the payload of a telecommunications satellite.** Since the radio waves transverse long distances, the carrier signals are received by the satellite at a very low power. Hence, the power level of these signals need to be boosted by satellites significantly before re-transmission back to

TABLE 10.3 Various Frequency Bands and Their Uses in ICT

| S.No. | Band name | ITU Band | Frequency | Example Uses |
|---|---|---|---|---|
| 1. | Extremely Low Frequency (ELF) | 1 | 3–30 Hz | Communication with submarines |
| 2. | Super Low Frequency (SLF) | 2 | 30–300 Hz | Communication with submarines |
| 3. | Ultra Low Frequency (ULF) | 3 | 300–3,000 Hz | Submarine communication, communication within mines |
| 4. | Very Low Frequency (VLF) | 4 | 3–30 kHz | Navigation, time signals, submarine communication, wireless heart rate monitors, geophysics |
| 5. | Low Frequency (LF) | 5 | 30–300 kHz | Navigation, time signals, AM longwave broadcasting (Europe and parts of Asia), RFID, amateur radio |
| 6. | Medium Frequency (MF) | 6 | 300–3,000 kHz | AM (medium-wave) broadcasts, amateur radio |
| 7. | High Frequency (HF) | 7 | 3–30 MHz | Shortwave broadcasts, RFID, over-the-horizon radar, radio communications, marine and mobile radio telephony |
| 8. | Very High Frequency (VHF) | 8 | 30–300 MHz | FM, television broadcasts, line-of-sight ground-to-aircraft and aircraft-to-aircraft communication, land mobile and maritime mobile communications, amateur radio, weather radio |
| 9. | Ultra High Frequency (UHF) | 9 | 300–3,000 MHz | Television broadcasts, microwave oven, microwave devices/ communications, radio astronomy, mobile phones, wireless LAN, bluetooth, GPS, amateur radio, satellite radio, remote control systems |
| 10. | Super High Frequency (SHF) | 10 | 3–30 GHz | Radio astronomy, microwave devices/communications, wireless LAN, modern radars, communications satellites, cable and satellite television broadcasting, amateur radio, satellite radio |
| 11. | Extremely High Frequency (EHF) | 11 | 30–300 GHz | Radio astronomy, microwave remote sensing, amateur radio, directed-energy weapon, wireless LAN (802.11ad) |
| 12. | Terahertz or Tremendously High Frequency (THz or THF) | 12 | 300–3,000 GHz | Experimental medical imaging to replace X-rays, spectr remote sensing, amateur radio (AM radio) |

Earth, ensuring that they are detectable by an Earth-based receiver.

Satellites have multiple uses on the basis of their own payloads. A satellite is not only used for telecommunications but also for many other applications in astronomy, weather forecasting, broadcasting, mapping, etc. Many transponders are used in satellite with specific frequency bands for various applications. **If we use lower frequency band, there will be more congestion.** Different technological innovations are behind the use of these bands and now we have achieved the use of higher band without restrictions. Different types of transponders used in satellite for various purposes are given in Table 10.4.

## 10.8 VERY SMALL APERTURE TERMINAL (VSAT)

A Very Small Aperture Terminal (VSAT) represents a **two-way satellite ground station** or may be called an **Earth-bound station.** Its application is in satellite communication of data, voice and video signals. **VSAT can handle up to 56 kilobytes per second. Its most common application is in point-of-sale transactions, such as applications of credit cards and RFID (Radio Frequency Identification).** The other extensive use of VSAT technology is by stockbrokers. **Across the globe, these services are used as method of providing access to broadband Internet sites, which do not have any ADSL or cable Internet access, generally in remote or rural locations.** Almost all VSAT systems are IP-based along with a very broad application range.

There are two typologies of VSAT: **Star VSAT** and **Mesh VSAT.** The deployment of these topologies depends on their commercial viability. Mesh VSAT systems are preferred where the number of users is high since the overall cost of the network is minimised. For broadband WAN or broadband Internet access, Star topology services can be deployed. They are also useful

**TABLE 10.4 Different Types of Transponders, their Frequencies and Uses**

| Transponder BAND | Range of Frequency | Application |
|---|---|---|
| L | 1 to 2 GHz | Global Positioning System (GPS) carriers and also satellite mobile phones, such as Iridium and Inmarsat provide communications at sea, land and air; WorldSpace satellite radio. |
| S | 2 to 4 GHz | Weather radar, surface ship radar and some communication satellites, especially those of NASA for communication with ISS and Space Shuttle. |
| C | 4 to 8 GHz | Primarily used for satellite communications, for full-time satellite TV networks or raw satellite feeds, tropical rainfall, since it is less susceptible to rainfade than Ku band. |
| X | 8 to 12.5 GHz | Military Application and Metrological Satellite, used in radar applications, synthetic aperture radar and phased arrays, weather monitoring, air traffic control, maritime vessel traffic control, defence tracking and vehicle speed detection. |
| Ku | 12.5 to 18 GHz | Broad casting Satellite Service (BSS), Internet, DTH, Satellite news gathering, Business Networking, VSAT services (Very Small Aperture Terminal), used for satellite communications. |
| K | 18 to 26.5 GHz | BSS and FSS (Fixed Satellite Services). |
| Ka | 26.5 to 40 GHz | FSS, VSAT services, communications satellite, high-resolution, close-range targeting radars on military aircraft. |

in the applications of front and back office and manage, store and forward solutions like digital signature and interactive distance learning.

## 10.9 SIM CARD (SUBSCRIBER IDENTITY MODULE) AND eSIM

It is an integrated circuit chip, mainly comprising of unique serial and international mobile subscriber identity number, security authentication and ciphering information. The card consists of temporary information pertaining to the local network, user's accessible services list and two passwords, one is for ordinary use, which is a Personal Identification Number (PIN) and the other is a personal unblocking code for blocking of PIN. It is mainly used in GSM phones, and can be used in satellite phones. Network operator '**Radiolinja**' developed first SIM card in **Munich, Germany in 1991.** SIM have security number, i.e. IMSI (International Mobile Subscriber Identity Number).

### eSIM

An eSIM is an embedded SIM, essentially the same hardware as a regular SIM card chip, but now a permanently embedded part of the motherboard of a watch or smartphone. eSIMs were first established a decade ago in 2012, but despite their futuristic use-cases, have not completely made physical SIMs obsolete yet.

#### *Advantages of eSIMs*

- Being attached to the motherboard also allows re-programming, letting users switch operators without having to replace any physical SIM cards.
- **Convenience:** The ability to store multiple SIM profiles in your eSIM also means you can switch between profiles easily.
- **Security:** There is no physical element to pull out and use in another device.

#### *Disadvantages of eSIMs*

- **Emergencies:** If your phone stops working, runs out of battery or simply, falls and gets a cracked screen, your communication is brought to a complete stand still with eSIMs.
- **Unusable in countries with no eSIM support:** You cannot use an eSIM phone in a country where the telecom operators simply do not support the technology yet.
- **Support only available in premium phones:** In India, eSIM support is currently available on more expensive devices like the Apple iPhones, and Google Pixel series.

## 10.10 IMEI (INTERNATIONAL MOBILE EQUIPMENT IDENTITY NUMBER)

It is a 15-digit unique number used for identification of mobile phones, as well as some satellite phones. Usually, it is printed inside the battery compartment of the phone. It can also be displayed on the screen of the phone by dialling *#06# in the keypad on most of the phones to display the IMEI number of the respective phone.

The GSM network uses IMEI number to identify valid devices and hence, a stolen phone can be stopped from accessing the network in the respective country. For instance, in case a mobile phone is stolen, using the IMEI number, the owner can call his or her network provider to 'ban' the phone. This makes the phone useless in that country, no matter if the phone's SIM is changed or not.

### *Security Concerns*

In many countries, including India, it is compulsory for every phone to have an IMEI number. The 15-digit number is critical for tracking any handset whether it is lost or stolen or needs to be monitored by security agencies. It is possible to track an individual with the IMEI number of his phone, even if he changes his service provider. Without IMEI number, the mobile phones are considered a grave security threat and hence, several concerns have been raised over their usage for terrorist attacks. **The government had banned imports of mobile phones without IMEI numbers from China in June 2009.** In December 2009, the Government of India had asked mobile operators to discontinue services to the customers whose phones do not have an IMEI number.

## 10.11 GENERATION OF MOBILE PHONES

Since early 1970s, the mobile wireless industry had started its technology creation, revolution and evolution as well. 0G to 4G have been experienced by mobile wireless technologies in the world. Cellular technology has evolved through generations, which are described below:

### 10.11.1 0G/Radio Phone or Taxi Phone

- In pre-cell days, we people talk to mobile operator to set up the calls and there were only a handful of channels available.

**CHRONOLOGY OF CELLULAR TECHNOLOGY**

- The evolution of cellular technology can be tracked back to 1979, when the first-generation mobile phones using analogue networks evolved in Japan.
- The second-generation systems using digital technologies (such as GSM and CDMA) began in Finland in 1991.
- The third-generation systems (supporting high-speed data and voice services) again began in Japan in 2001.
- Fourth-generation technology firstly-released Long-Term Evolution (LTE) standard and has been commercially deployed in Oslo, Norway and Stockholm, Sweden since 2009.
- 5G deployments arguably started in 2018 in the USA but got properly underway in 2019 with many EU countries offering a limited service in cities. This developed throughout 2020 and by the end of the year, there had been commercial 5G launches in all EU countries with only four exceptions.

- 0G refers to pre-cell phone-based mobile telephony technology, such as radio telephones or taxi phones that some had in cars before the advent of cell phones.
- In this technology, **transceiver was mounted in the vehicle and the 'head' (dial, display and handset) was mounted near the driver seat.** It was used only for basic voice communication. **This technology was firstly used in Finland, 1971.**

### 10.11.2 1G FDMA: Frequency Division Multiple Access

- It refers to the first generation of wireless telephone technology (mobile telecommunication), which was first introduced in 1980s and completed in early 1990s.
- **This generation was setup with the help of tower and its range (i.e. a 'Cell').**
- Its **speed was up to 2.4 kilobytes per second.**
- 1G network uses analogue signal.

**Drawbacks** Poor battery life, poor voice quality, large phone size, no security, limited capacity and poor hands off reliability.

### 10.11.3 2G TDMA: Time Division Multiple Access and CDMA: Code Division Multiple Access

- It refers to the second generation, which is based on TDMA and CDMA **(GSM is one of the TDMA Variant).**
- It was launched in 1991.
- This network uses **digital signals.**
- Its data speed was up to **64 kilobytes per second.**
- Features enable services such as **text messages** and provide better quality and capacity.

**Drawbacks** It is totally based on network coverage work with strong digital signals at which mobile phones work. If there is loss of network coverage in any specific area, digital signals would weaken. These systems are unable to handle complex data such as videos.

### .4 2.5G GPRS: General Packet Radio Services

- This **technology works with GSM Network.**
- It refers to the technology between second (2G) and third (3G) generation of mobile telephony. 2.5G can also be described as 2G cellular technology combined with 'General Packet Radio Services' (GPRS).

**Features:** Phone calls, send/receive email messages, **WAP (Wireless Application Protocol) services**: web browsing and surfing, MMS (Multimedia Messaging Services) and **speed: 64–144 kilobytes per second,** camera phones, take a time of 6–9 minutes to download a 3-minute MP3 song.

### 10.11.5 2.75G EDGE: Enhanced Data Rates for GSM Evolution

- This technology **also works in GSM networks.**
- It is an extended version of GSM, which allows faster transmission of data and information than GPRS. EDGE is a radio technology and it is also a part of third-generation technologies. EDGE technology evolved with certain handsets like **BlackBerry, N97 and N95 mobile phones.**
- **EDGE was three times faster than GPRS.** During the use of EDGE technology, there was no need to install any additional hardware and software. There are no additional charges for using this technology.
- A person having GPRS technology can utilise this technology without paying any other additional charges.

### 10.11.6 3G UMTS: Universal Mobile Telecom Services, EDGE: Enhanced Data Rate for GSM Evolution and CDMA 2000/WCDMA

- 3G technology refers to third generation that was introduced in year 2000.
- Its data transmission speed increased from **144 kilobits per second to 2 megabits per second.** This is typically called as **smart phones** where features increased with bandwidth.

**Features:** Faster communication, high-speed web/ more security, video conferencing, TV streaming and send/receive large email messages.

**Drawbacks:** This technology is expensive to find this licence services and also challenging to build the infrastructure for 3G. Requirement of high bandwidth, 3G phones are expensive 3G, larger size of cell phones.

**Note:** Some more generations evolve between 3G and 4G, i.e. 3.5 G: HSDPA (High Speed Downlink Packet Access ) and **3.75 G: HSUPA** (High Speed Uplink Packet Access)

### 10.11.7 4G LTE: Long-Term Evolution, HSPA+: High Speed Packet Access Plus, VoLTE

- This generation was started from late 2000s.
- It is capable of providing **100 megabits per second to 2 gigabits per second speed.**
- 4G is also described with the name of **MAGIC** (M = Mobile Multimedia, A = Anytime Anywhere, G = Global Mobility Support, I = Integrated Wireless Solution, C = Customised Personal Services).
- Higher data rate and also provides expanded multimedia services.
- Higher level of security.

**Drawbacks:** Battery usage is more, need very complicated hardware, expensive equipment is required to implement these network.

### 10.11.8 5G

5G is the next generation of mobile broadband that will eventually replace, or at least augment 4G LTE connection.

### *Features and Benefits of the 5G Technology*

- Operate **in the millimetre wave spectrum (30-300 GHz)** which have the advantage of sending large amounts of data at very high speeds.
- Operate in **3 bands,** namely low, mid and high frequency spectrum.
- **Reduced latency** will support new applications that leverage the power of 5G, the Internet of Things (IoT), and artificial intelligence.
- **Increased capacity** on 5G networks can minimise the impact of load spikes, like those that take place during sporting events and news events.

### *Challenges for 5G Roll-out in India*

- **Procedural Delays:** India's telecom sector is greatly affected by the procedural delays and their multiple issues.
- **Affordability of Spectrum:** Many countries around the world may already roll out 5G connectivity to its users but in India, the 5G spectrum is yet to be allocated.
- **Last-mile Connectivity:** Catering to last-mile broadband connectivity in Tier-II, Tier-III cities and rural homes are challenging since India lacks optical fibre infrastructure and greenfield deployment which has immensely affected last-mile connectivity.
- **Affordable 5G Devices:** On the consumer front, affordable 5G devices are yet to take their place in the market.

### *Significance of the Technology*

- India's **National Digital Communications Policy 2018** highlights the importance of 5G when it states that the convergence of a cluster of revolutionary technologies including 5G, the cloud, Internet of Things (IoT) and data analytics, along with a growing start-up community, promise to accelerate and deepen its digital engagement, opening up a new horizon of opportunities.

### *Potential Health Risks from 5G*

- To date, and after much research performed, **no adverse health effect has been causally linked with exposure to wireless technologies.**
- **Tissue heating** is the main mechanism of interaction between radiofrequency fields and

**TABLE 10.5** Comparison among Various Mobile Generations

| Characteristics | 2G | 3G | 4G | 5G |
|---|---|---|---|---|
| Introduced year | 1993 | 2001 | 2009 | 2018 |
| Technology | GSM | WCDMA | LTE, WiMax | mm waves (Millimetre waves) |
| Frequency Band (Bandwidth) | 25 MHz | 25 MHz | 100 MHz | 30 GHz – 300 GHz |
| Speed | 64 Kbps | Upto 3.1 Mbps | Upto 1 Gbps | Upto 10 Gbps |
| Advantages | Multimedia features (SMS, MMS), Internet Access, SIM Introduced | High Security, International Roaming | High Speed hadoffs, Global Mobility | Extremely High Speeds, Low Latency |
| Services and Applications | Voice calls, Short Messages | Video Conferencing, Mobile TV, GPS | High Speed Applications, Mobile TV, Wearable devices | High Resolution Video sharing, Remote control of vehicle, Robots & Medical Procedures |

Note:

- **3G versus 4G:** 3G, a complete new innovation transformed the mobile telephony. It provided voice and data connectivity on a single network, for the first time, accelerating new ideas like e-learning, e-governance, etc. An improved bandwidth and speed of communication were achieved. 4G was highly concentrated on bandwidth enhancement and improved speed, further taking 3G to the next level. The two existing technologies in 4G are: 4G LTE and 4G WiMAX. The real difference between 3G and 4G is its difference in speed.
- **4G LTE versus 4G WiMAX:** Long-Term Evolution or LTE is a first-generation 4G technology termed as 'true 4G'. WiMAX stands for Worldwide Interoperability for Microwave Access. LTE has higher bandwidth than WiMAX. LTE is compatible with existing networks but WiMAX works on new network. Overall, LTE is gaining lot of popularity as 4G network.
- **5G: Millimetre wave (MM wave)/ millimetre band** is the band of spectrum with wavelengths between 10 millimetres (30 GHz) and 1 millimetre (300 GHz). It is also known as the extremely high frequency (EHF) band by the International Telecommunication Union (ITU).
  **Advantages of millimetre wave:** Millimetre wave is a band of electromagnetic spectrum that can be used in a broad range of products and services, such as high-speed, point-to-point wireless local area networks (WLANs) and broadband access. In telecommunications, millimetre wave is used for a variety of services on mobile and wireless networks, as it enables higher data rates than at lower frequencies, such as those used for Wi-Fi and current cellular networks.

the human body. Radiofrequency exposure levels from current technologies result in **negligible temperature rise in the human body.**

- **As the frequency increases, there is less penetration into the body tissues** and absorption of the energy becomes more confined to the surface of the body (skin and eye).
- Provided that the overall exposure remains below international guidelines, **no consequences for public health are anticipated.**

*International Exposure Guidelines*

- Two international bodies produce exposure guidelines on electromagnetic fields. Many countries currently adhere to the guidelines recommended by:
  1. The International Commission on Non-Ionising Radiation Protection.
  2. The Institute of Electrical and Electronics Engineers, through the International Committee on Electromagnetic Safety.
- These guidelines are not technology-specific. They cover radio frequencies up to 300 GHz, including the frequencies under discussion for 5G.

*International Efforts – International Electromagnetic Fields (EMF) Project*

- WHO established the International Electromagnetic Fields (EMF) Project in 1996. The project investigates the health impact of exposure to electric and magnetic fields in the frequency range 0–300 GHz and advises national authorities on EMF radiation protection.

*Where does India stand in terms of trials and launch?*

5G services were first launched in India by Prime Minister Narendra Modi on October 1, 2022. At present, only Bharti Airtel and Reliance Jio are the two telecom operators that offer 5G networks in the country.

According to the recently released 'Ericsson Mobility Report':

- Fifth generation telecom services are likely to account for 39% of mobile subscriptions or about 500 million subscriptions in India at the end of 2027.
- The total number of smartphone subscriptions was expected to be 810 million at the end of 2021 and would be projected to grow at a compounded annual growth rate of 7%, exceeding 1.2 billion by 2027.
- 4G subscriptions are expected to reduce from 68% of mobile subscriptions in 2021 to 55% in 2027 as subscribers migrate to 5G.

Jio rolled out its 5G network in Bengaluru, Hyderabad, Gurugram, Noida, Ghaziabad and Faridabad in November 2022. Jio 5G was also made available in Pune in November 2022 and in all districts of Gujarat.

(Refer **Infographic – 4G vs. 5G**)

(Refer **Infographic – Standalone 5G vs Non-Standalone 5G**)

## 10.12 CERTAIN SERVICES AVAILABLE IN MOBILE PHONE TO ENHANCED INTERNET SPEED

### 10.12.1 Long-Term Evolution (LTE)

LTE or Long-Term Evolution, commonly marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals. For a true 4G technology, download speeds of 100 megabits per second and 1 gigabits per second should be available for moving (i.e., in a car) or pedestrian points, respectively.

The maximum download speed offered is of 300 megabits per second, although it has been controversial over the speeds provided by some operators running LTE networks. Sometimes the speed is lower than the supposedly 'inferior' HSPA (Plus) technology. Commercially available speed varies widely and using the (at the time of writing) recently launched UK LTE networks, tests have shown anywhere in between 8 and 50 megabits per second in available areas.

#### 10.12.1.1 Difference between LTE and VoLTE

LTE is called '**Long Term Evolution**'. **Airtel launched the first LTE network service in India in 2012.** Generally, LTE is also called 4G. VoLTE stands for '**Voice over Long Term Evolution**' or 'Voice over LTE'. It means that unlike 4G LTE, even calls, SMS, web browsing will be possible using your Internet data plans. **Reliance Jio had started this VoLTE service in India in 2016.** Now every major carrier supports it and every new phone should support it.

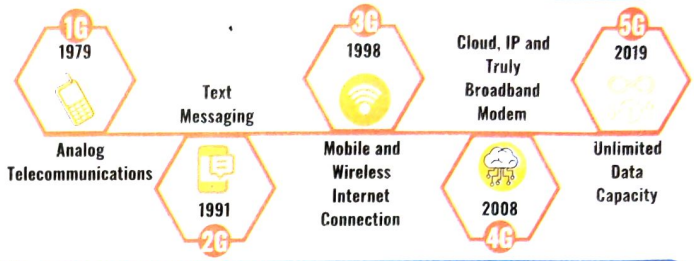
In April 2023, approximately 5.18 billion people around the world used the Internet.

# 4G vs 5G

## What is 5G?

- 5G enables a new kind of network that is designed to connect virtually everyone and everything together including machine, objects and devices.
- Contributes to the development of Smart Communities which aim to provide digital innovative services for their citizens.

## Evolution of Wireless Technology




## 4G

- 4G refers to fourth generation of mobile communications standards.
- The latency varies from carrier to carrier.
- 4G is relatively slower than 5G in terms of peak speed.
- 4G offers a minimum peak download speed of 1Gbps

| | |
|---|---|
| Latency | 200 milliseconds |
| Potential Download Speed | 1 Gbps |
| Base Stations | Cell Towers |
| Channel | 20 Mhz Channels |
| Energy Efficiency | 1X |
| Density | 100K Connections/km² |

## 5G

- 5G is the fifth generation of wireless network technology.
- It is built on what's called millimeter waves, a section of very high frequency spectrum upwards of 20 GHz all the way up to 96 GHz.
- 5G offers highly reduced latency capabilities compared to previous generations of wireless technology.
- In terms of peak speed, 5G is nearly 20 times faster than 4G.
- 5G provides a minimum peak download speed of 20Gbps.

| | |
|---|---|
| Latency | Less than 5 milliseconds |
| Potential Download Speed | 20 Gbps |
| Base Stations | Small Cells |
| Channel | 100-800 Mhz Channels |
| Energy Efficiency | 8100X |
| Density | 1 Million Connections/km² |

## PROS of 5G

**GREATER TRANSMISSION SPEED**
100 times faster than 4G

**LOWER LATENCY**
10 times less latency than 4G

**INCREASED CONNECTIVITY**
100 times increase in traffic capacity

**ENERGY EFFICIENCY PLANS**
5G network aims to decrease energy consumption by 10% as compared to 4G networks.

**EFFICIENT BUSINESS PROCESS**
5G technology allows enterprises to coordinate all the devices under their control with infinite efficiency.

## CONS of 5G

**COST OF ESTABLISHMENT**
Replacement of existing mobile infrastructure, skilled workers to maintain a proper connection.

**LACK OF INFORMATION**
5G technology is still in developing phases and there is a lot left to be discovered.

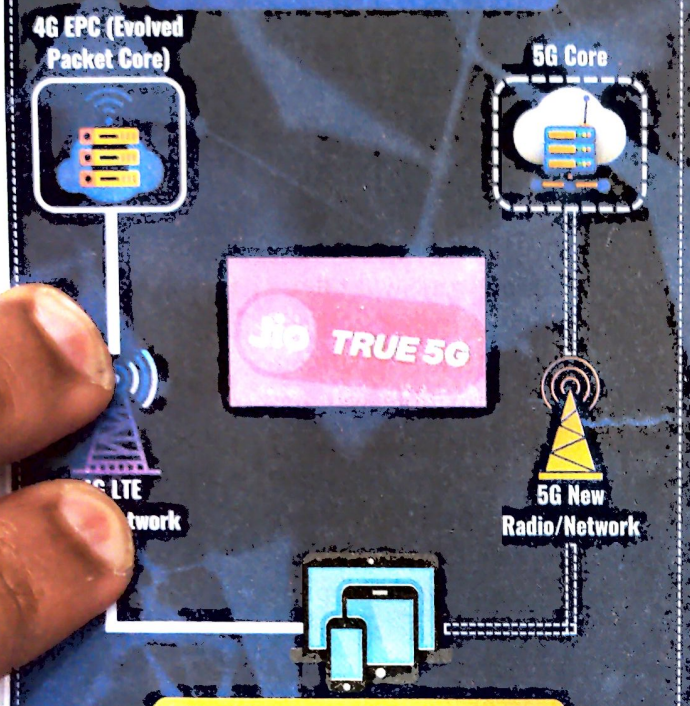
**LIMITED COVERAGE**
5G waves- millimeter waves, generally have very low penetrating power and cannot pass through buildings, trees, walls or other barriers without signal being disrupted.

**OVERCROWDED RADIO FREQUENCY**
5G network is 6Ghz, which is already jam-packed with other signals

**SECURITY AND PRIVACY ISSUES**
Feature of allowing the transfer of high quality data and the presence of more entry points for attackers.

# 5G STANDALONE VS NON-STANDALONE 5G

## STANDALONE 5G




**Standalone uses a 5G Core to manage connectivity and user authentication.**

Standalone 5G represents a more advanced phase of 5G deployment, where it operates independently without relying on the existing 4G infrastructure. In SA deployments, both the 5G RAN and the core network are upgraded to fully support 5G capabilities. The 5G core network (5GC) is introduced, which is specifically designed to handle the requirements of 5G services.

### KEY CHARACTERISTICS

- Operates independently of 4G networks, allowing for the full potential of 5G to be realized.
- Introduces a new 5G core network (5GC) that provides advanced features like network slicing, ultra-low latency, and improved service orchestration.
- Enables new use cases and applications that require the unique capabilities of 5G, such as autonomous vehicles, massive IoT deployments, and ultra-reliable low-latency communication (URLLC).
- Requires a complete upgrade of both the RAN and core network infrastructure, which may take longer to deploy compared to NSA.

### DEFINITION

- Dedicated 5G network employs specialized equipment and network functions.
- It combines 5G radios with cloud-native, service-based core network functions.
- The network functions are completely virtualized and designed for cloud-native operation.

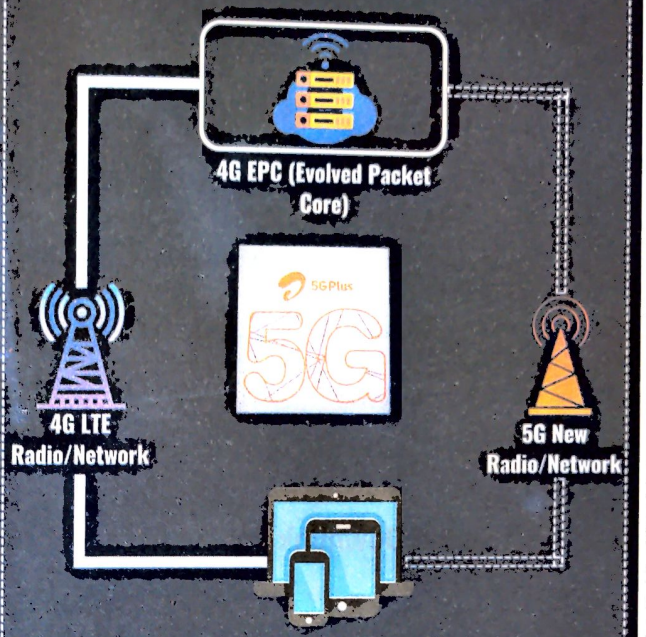
### PROS OF STANDALONE 5G

- Full range of 5G capabilities including enhanced Mobile Broadband (eMBB), Ultra-Reliable Low Latency Communication (URLLC), and Massive Machine Type Communication (MMTC).
- Enables new features, functionality, and services such as network slicing for customized service delivery.
- Offers a flexible architecture that allows dynamic linking of network functions to enhance scalability and adaptability.

### CONS OF STANDALONE 5G

- Involves a greater level of investment compared to other deployment options.
- Requires organizational training for the operation of 5G core and services.
- Demands preparation and knowledge-building within the organization for effective implementation of 5G core and services.

## NON-STANDALONE 5G




**Non-Standalone uses a 4G Control Panel to manage connectivity and authorization**

Non-Standalone 5G refers to the early deployment phase of 5G networks, where 5G is integrated with existing 4G infrastructure. In NSA deployments, 5G relies on the underlying 4G network for control functions, such as signaling and mobility management. The 5G radio access network (RAN) is connected to the 4G core network (EPC - Evolved Packet Core), which handles core network functions.

### KEY CHARACTERISTICS

- Relies on the existing 4G infrastructure for control plane functionalities.
- Uses the 5G radio interface (NR - New Radio) for data transmission, offering higher speeds and lower latency compared to 4G.
- Provides improved data rates and capacity compared to 4G, but may not fully realize the potential of 5G.
- Allows for faster deployment as it leverages the existing 4G infrastructure.

### DEFINITION

- 5G network relies on the existing 4G core infrastructure for support.
- It utilizes 5G radios coupled with the LTE Evolved Packet Core (EPC).
- Some network functions are hosted on dedicated appliances, depending on the scenario.

### PROS OF NON- STANDALONE 5G

- Enables quicker deployment and serves as a transitional step towards Standalone (SA) deployment.
- Maximizes the utilization of current network assets for a more efficient rollout.
- Requires a lower investment compared to SA deployment.

### CONS OF NON- STANDALONE 5G

- Exhibits a less flexible architecture compared to other options.
- Offers limited scope for incremental 5G functionality.
- Provides a narrower range of additional features and capabilities compared to alternative deployment approaches.

**LTE vs. VOLTE**

| LTE | VoLTE |
|---|---|
| 1. It stands for 'Long Term Evolution'. | 1. It stands for 'Voice over Long Term Evolution'. |
| 2. External software like WhatsApp, Facebook Messenger and Skype are required by users to make video calls on LTE networks. | 2. Only the phone number is required to video call anybody. |
| 3. There is a possibility that LTE may not support voice calls and data services together. | 3. It supports voice calls and data services together. |
| 4. It targets increasing data rates on the 4G bandwidth only. | 4. It targets both internet data and voice calling without affecting each other. |
| 5. The time limit to connect a call on 3G networks is comparatively slow in case of LTE. | 5. The connectivity is comparatively high provided both the users are on the VoLTE network. |

### 10.12.2 High Speed Downlink Packet Access (HSDPA)

High Speed Downlink Packet Access (HSDPA) is 3G network-based technology, which can support speeds up to 7.2 megabits per second. Practically, it is likely to get a top speed of around 3 megabits, yet it is useful for mobile TV streaming and other high-end data transmissions. To use HSDPA, first the phone should be compatible for the technology plus the location of the device should be within range of a cell site that has been upgraded to offer the service.

### 10.12.3 High Speed Packet Access Plus (HSPA+)

An evolved version of HSPA (HSDPA and HSUPA) standard is HSPA (Plus), which enables faster speeds. The maximum download speed allowed by the standard is 168 megabits per second, although in real sense, supporting network will offer 21 megabits per second download. This is due to the fact that the existing 3G network architecture operators would have deployed and made compatible was never designed to handle such massive bandwidth.

Hence, the operators need additional spectrum for improving the quality of services. The Government should formulate a spectrum policy promoting efficient use of spectrum *via* development of market incentives and differential pricing of spectrum in congested areas. The government can realise the best price for spectrum according to market forces, through open and transport auction format and simultaneously the telecom operators can minimise and efficiently use the spectrum.

## 11.1 EVOLUTION OF INTERNET

- **1969 AD: Advanced Research Project Agency (ARPA)** of American defence agency started the Internet **ARPANET** by placing the four universities of USA into a network. It was developed for the research education and government institution. It had another aim too for the emergency that if all the another medium of connection had failed, the connection could be established through it. Up till 1971 the ARPANET had connected approximately two-dozen computers.
- **1972 AD:** e-mail service started.
- **1973 AD:** Transmission Control Protocol/Internet Protocol (TCP/IP) was designed. Till 1983, it became the mode of communication between two computers. In this Internet, user could download files by connecting to any computer.
- **1983 AD:** The military part of ARPANET was transferred to MILNET.
- **1986 AD:** US National Science Foundation (NSF) launched NSFNET. It was the first-ever wide-range network in which the Internet technique was used.
- **1988 AD:** In Finland, Jorcco Occirenene developed Internet chatting.
- **1989 AD:** Peter Deutsch firstly tried to prepare the index of Internet. Brewster Kahle of thinking machine corporation developed another index WAIS (World Area Information Service).
- **1989 AD Tim Berners Lee** of CERN (European Laboratory for Particle Physics) developed a new technique for sharing the information on Internet. It was called World Wide Web (www). It is based on the hypertext, which connects Internet users from different sites. It happens through hyperlink (word, buttons or graphics programmed in a distinguished manner).
- **1991 AD:** First user-friendly interface. GOFAR was developed in Minnesota University (USA) henceforth, GOFAR has been a famous interface. NFSNET opened for commercial traffic.
- **1993 AD:** Marc Lowell Andreessen of National Centre for Super-computing applications developed a navigation system named 'Mosaic'.
- **1994 AD:** Netscape Communications and in 1995, Microsoft, rolled out their browsers in the market. Owing to these browsers, the use of Internet became very easy for users.
- **1995 AD:** Commercial sites were launched on Internet. Mass marketing campaign were started through e-mail.
- **1996 AD:** By 1996, the Internet became famous in the world. Number of Internet users reached up to 15 million.
- **1999 AD:** The concept of e-commerce gathered pace, due to which the shopping online through Internet became quite famous.
- **2003 AD:** In New Zealand, NIUE started a countrywide wireless access system in Internet.

## 11.2 INTERNET

Internet is the term used for the **wide area network/ global area network** that connects computers spread all over the world. It is the **network of networks**. Internet consists of interconnection of networks of various types. It is a public network. Through Internet, we can share text data, audio and video data. Nobody owns the Internet, it is governed by ISOC (Internet Society). Internet is also popular with the name of 'Network of Networks'.

Internet is the super network of computers worldwide. Through this, thousands of computers are connected worldwide. The journey of Internet was started by **Vint Cerf and Bob Kanh**. They devised a technique by which the formation could be divided into small packets and could be sent to another computer, so that the other computer could make a copy of this. It was a way of establishing communications between two computers. This technique was called **'Transmission Control Protocol' (TCP).**

The transmission of information can also be repeated when there are more than two computers in the network, because every computer has its own address in the network. This address is called **Internet Protocol (IP)** address, i.e., IP address. Internet Protocols are some numbers in fact, which are separated with a point with each other.

Information is sent to other computer in the broken form of small packets. When these packets reach a computer, the computer assesses whether this information is sent for it or not. It moves the data forward in the direction of that computer for which

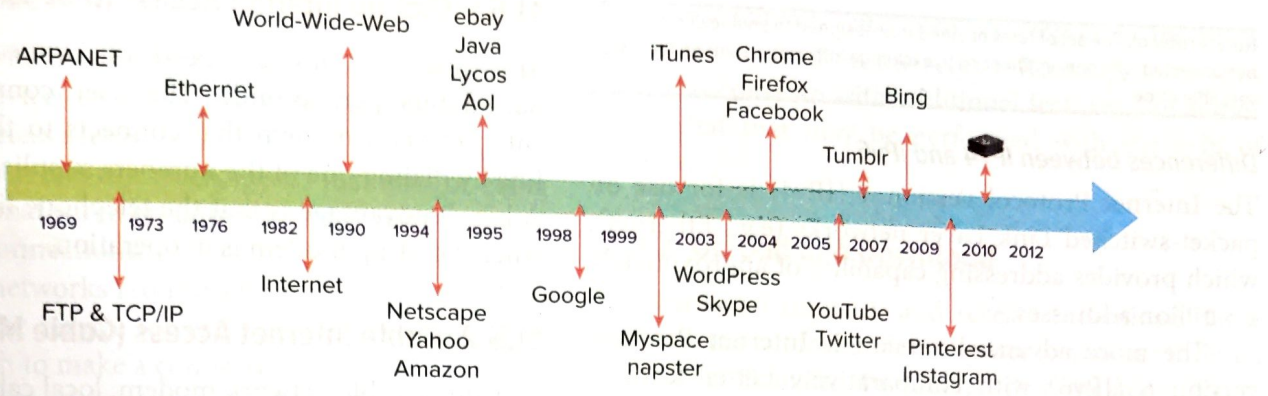



**Figure 11.1**
**Evolution of Internet Services**

the data is sent. So, the transportation of data from one point to another is called Internet protocol (IP).

Often, the computers of an office are connected to each other and transmit information with each other. This is called LAN. Any computer connected in LAN is connected with a telephone line or a satellite. All the computers in the world are connected to each other. Internet is the network for worldwide computers, which can interconnect (See Figure **11.1**).

## MODEM (MODULATOR-DEMODULATOR)

To connect the Internet through line or telecommunications line, a modem is required. It is a necessary link between the Internet service provider and the browser. Through telephone line, only analogue data can travel, whereas, a computer gives the digital data. To maintain compatibility in between computer system and a telephone line, a modem is needed, which converts digital signal to analogue and *vice versa*. The speed of modem is measured in bytes per second (BPs), kilobyte per second (Kbps), megabyte per second (Mbps), etc.

### 11.3.1 Internal Modem

It is the modem, which is already inside our desktop or laptop. The mobiles and other electronic devices in which we use Internet are the examples of gadgets having internal modem.

### 11.3.2 External Modem

The external modem has to be connected to our computer from outside. Such types of modems are used in data cards (Photon, Idea, etc.) or PCMCI. So modem is a device that lets your computer send signals back and forth along a telephone line.

### 11.3.3 Internet Software or Web Browser

Web is like a large book and web browser is a software, which connects computer to the Internet. Some web browsers are

- Netscape navigator
- Microsoft Internet explorer
- Mozilla Firefox
- Google chrome
- Opera

We can get the knowledge through connecting these browsers. URL (Universe Resource Locator) has both, the tools to be used and the address of Internet. In the URL *http://www.google.co.in* tool *http (hypertext transfer protocol)* is a protocol, means a predefined rule that sends the information to the given Internet address.

## 11.4 INTERNET PROTOCOL

It represents the set of rules that govern sending/receiving messages on Internet. The data sent from one computer to another, on the Internet, follows this protocol. The communicating end-point has no continuing connection, and is hence termed as connection-less protocol.

Note: **Protocol:** The set of rules or standards designed to enable computers to be connected with one another and to exchange information among them with very little error.

### *Differences between IPv4 and IPv6*

The Internet Protocol version 4 (IPv4) is for use on packet-switched Link Layer networks (e.g., Ethernet), which provides addressing capability of approximately 4.3 billion addresses.

The more advanced version is Internet Protocol version 6 (IPv6) with comparatively better features (**Table 11.1**). Capable of providing an infinite number of addresses, IPv6 is replacing IPv4, thereby accommodating the growing number of networks worldwide. This also helps to solve the IP address exhaustion problem.

**TABLE 11.1 Differences between IPv4 and IPv6**

| Features | IPv4 | IPv6 |
|---|---|---|
| IP Address (No. of bits) | 32 | 128 |
| Format | Decimal | Hexa-decimal |
| Addresses Capability | 4.3 billion | No limitation (infinite number) |

A major difference between the two is the way the IP addresses appear. IPv4 uses four 1 byte decimal numbers, separated by a dot (i.e., 192.168.1.1). IPv6 uses hexadecimal numbers separated by colons (i.e., fe80:d4a8:6435:d2d8:d9f3b1:1).

### *Advantages of IPv6 over IPv4*

- The router's work got comparatively simpler via IPv6.
- IPv4 is less compatible to mobile networks than IPv6.
- The payload allowance of IPv6 is higher than that of IPv4.
- In spite of all these remarkable differences, currently, IPv4 shares larger user portion (99 per cent) while the share of IPv6 is merely 1 per cent of the networks.

## 11.5 WAYS OF ACCESSING INTERNET

There are six common ways of accessing the Internet offered by service providers.

### 11.5.1 Dial-up Internet Access (Dial-up Modem)

This one has slowest speed of connection (about 60 kilobits per second). The user connects to the Internet via a modem that connects to the telephone line by dialing one of the numbers supplied by the ISP. A big disadvantage is that the telephone line is tied up when a dial-up modem is in operation.

### 11.5.2 Cable Internet Access (Cable Modem)

By using a cable network modem, local cable television operators give a user access to the Internet through their own cable networks.

### 11.5.3 Internet Access via DSL (Broadband Modem)

DSL broadband connections maintain the fastest download speeds (at least 11,000 kilobits per second).

- It is often offered with wireless interface, which requires an Access Point and a router.
- ISPs usually have a download/upload limit (e.g., 10 gigabyte of data) as part of the contract.
- Through the help of this system, Voice over IP (VoIP) and online chat rooms can be used effectively.

### 11.5.4 Wi-Fi Broad Band

This facility requires a Wi-Fi card attached to the computer and a wireless modem.

### 11.5.5 Satellite Services

Broadband Internet access in rural or outlying areas is taken care by satellites, as these places are still not fully accessible by wired phone lines or cable connections.

- The broadband option requires an unobstructed aiming path between a small dish and the orbiting satellite. Hence, it is similar to a satellite TV service, except it runs on different antennas and receiving equipment.
- The antenna is connected to a modem device via wires and then connected to your computer.
- The bandwidth and uptime can be interrupted by the same forms of service interruption degrading satellite TV signals, including rain, snow and high wind.

### 11.5.6 Mobile Methods

The mobile methods like full-featured smart phones and tablet devices enable us to conduct online activities through wireless access.

- These services can reach speeds that rival or equal traditional wired broadband, inclusive of DSL and cable connections.
- These networks require a location close enough to a cellular service tower to provide enough signal strength to make a connection.
- A USB modem device is plugged to the laptop or computer to access wireless service, or the phone is connected to the computer to share the bandwidth. Such sharing process is known as tethering, which involves additional fee payment to the mobile phone service provider.

## SERVER

A programme that uses the client/server model and the World Wide Web's hypertext transfer protocol (http) is termed as a web server. This programme services the files that form web pages to web users. Every computer containing a website on the Internet must have a web server programme. Apache is the most widely installed web server. Apache and Microsoft's Internet Information Server (IIS) are two leading web servers.

## 11.7 WEBSITE

It is a collection of web pages, typically common to a particular domain name or sub-domain on the World Wide Web.

## 11.8 WEB PAGE

A Web Page is a resource on the World Wide Web, usually in HTML/XHTML format with hypertext links enabling navigation from one page or section to another. Web Page contains dynamic content (e.g., images, text, form fields, etc.) that can change/move without reloading the web page.

## 11.9 SERVICES ON INTERNET

### 11.9.1 Chatting

Instant messaging or chatting is a type of communication, wherein the participants type messages to other chat group participants and receiver responses instantly, which can be read on the screen. Recently, some sites have also come up with additional features like audio/video chat that may be performed with the help of webcam.

### 11.9.2 Upload and Download

You can send (upload) and receive (download) large files over the net from one computer to another through FTP (File Transfer Protocol). This includes Word, EXCEL or of any other format file.

### 11.9.3 Gopher

All the available resources on the Internet are shown by Gopher in the form of menus. The concept of Gopher is based on the clients and servers.

### 11.9.4 Search Engine

A programme that searches documents for specified keywords and returns a list of documents where the keywords are found is known as search engine.

Note: Search engines introduced earlier: LYCOS (1993), WEB CROWLER in (1994), Yahoo and ALTA VISTA in 1995, GOOGLE (1998). Microsoft introduced BING as its search engine.

## 11.10 EMAIL PROTECTION AGAINST VIRUS

In digital communication, the security over Internet becomes most important and given below are some characteristics of e-mail messages and attachments indicating that they are unsafe to open:

- e-mail from an unknown sender;
- e-mail from a known sender, but subject line does not make sense;
- Message attachment with filename extension associated with viruses;
- Messages containing links to destinations unrecognisable to the user.

Users will successfully avoid virus infection by applying knowledge of these e-mail characteristics and taking appropriate action when reading e-mail (i.e., open message or delete it).

Various types of problem appear through Internet.

### 11.10.1 E-mail Spoofing

When the sender's address and other parts of the e-mail header are altered to appear as though the e-mail originated from a different source, it may indicate E-mail spoofing. Since the core SMTP does not provide any authentication, impersonation and forging the emails becomes easy.

In terms of network security, a spoofing attack represents a situation in which one person or programme successfully masquerades as another by falsifying data and thereby gaining an illegitimate advantage.

### 11.10.2 Spywares

Spyware is installed with or without permission on the personal computers to collect information about users, their computer or browsing habits track each and everything that is done without the user's knowledge and sends it to remote user. Other malicious programmes can also be downloaded via spyware from Internet and installed on the computer. Similar to adware in function, but it is usually a separate programme installed unknowingly while installing another freeware-type programme or application.

### 11.10.3 Adware

Generally, it is a software application, which displays advertising banners during the running of any programme. While browsing any website, adware can automatically get downloaded to the system and can be viewed through pop-up windows or through a bar appearing on a computer screen automatically. Companies use adwares for marketing purposes.

### 11.10.4 Spam

When Internet is flooded with copies of the same message, it is termed as spamming. Mostly, spams include commercial advertisements sent as an unwanted email to users. Another name for spams is electronic junk mails or junk newsgroup postings. Such electronic junk emails are annoying, as they keep coming everyday, making the mailbox full.

### 11.10.5 Tracking Cookies

It is a plain text file stored in given computer in cookies folder, thereby storing data about the browsing session. Many websites deploy cookies to track visitors' information. Since cookies keep track of the browsing history, it can be dangerous to access personal important details like bank account details, credit card information, etc., because via cookies, the hackers and companies may access all such personal details.

## 11.11 UNIFORM RESOURCE LOCATOR (URL)

A formatted text string called URL is used by Web browsers, to identify a network resource on the Internet network resources such as a file that can include plain Web pages, other text documents, graphics or programmes.

## 11.12 TYPES OF DOMAIN

Various types of domains are used on the Internet to distinguish different types of websites.

- .com commercial
- .edu or ac educational
- .mil military
- .net belonging to networking or Internet service provider company
- .org organisational
- .gov government
- .info informational sites

## 11.13 HYPER TEXT TRANSFER PROTOCOL (HTTP)

A file can be transferred over the World Wide Web *via* FTP (file transfer protocol) or HTTP (Hypertext Transfer Protocol). HTTP represents the set of rules for transferring files (text, graphic images, sound, video; and other multimedia files) on the World Wide Web. The moment the Web user opens the Web browser; HTTP comes into play. HTTP is an application protocol running on top of the TCP IP suite of protocols, while FTP is used to transfer bulk files.

Note: HTTP protocol for communication between web browser and servers

## 11.14 WEB BROWSER

Web browser is used to access the World Wide Web. Since they get information from a server, they are also referred to as Web clients. When WWW browser is started or a hyperlink is followed, the browser (acting

like a client) sends a request to a site on the Internet. That site (acting like a server), then returns a file, which the browser then has to display. Types of Browser Different types of browsers available include **Mosaic, Netscape navigator, Internet Explorer, Mozilla Firefox, Safari, Opera, Google chrome, etc. First web browser Mosaic was developed in 1993**. Netscape Navigator was the second browser developed in 1994 and Microsoft introduced Internet Explorer as a browser in 1995.

## 11.15 EVOLUTION OF WEB (WEB 1.0, 2.0, 3.0 AND 5.0)

### Web 1.0

- Early internet that persisted until about 2000.
- It was the version of the internet that existed before social media and video streaming.
- Websites were just places you could read the information posted on servers and interact with such servers in simple ways.
- There were search engines, and there were e-commerce sites like AltaVista, Netscape, Amazon and eBay.

### Web 2.0

- It started roughly around 2003 when the term was coined by Dale Dougherty, Vice President at O'Reilly Media.
- It is far more interactive, far more collaborative, and far more capable as users were not mere idle visitors, they could create and upload their own content because of the improved bandwidth available to users, and servers.
- It is this generation of the web that gave us smart phones and mobile computing.
- Web 2.0 could support near real-time interactions and thus collaborative activity was feasible.
- Social networks like Facebook, Twitter and Instagram became part of this and also graphical multiplayer games came into picture.
- It also included the birth of Big Data and the machine learning algorithms that sifted through it.

### Web 3.0

- It is defined by intelligence.
- This intelligence is not just in interactions between people and websites, but between software and software.
- The model is a decentralised internet to run on blockchain technology and it would be different from the versions in use, Web 1.0 and Web 2.0.
- In Web 3.0 users will have ownership stakes in platforms and applications unlike now where tech giants control the platforms.
- Web 3.0 will be based on Inter-Planetary File System (IPFS).
- IPFS will replace the current DNS system (Web 1.0 and 2.0 work on DNS System).
- IPFS is also a postal system, but it is not centralised around a group of root servers like the HTTP protocol.

### Properties

#### *1. Digital Identities*

With Digital IDs, individuals can only have one verifiable identity, since each ID has to be linked to a unique credential, like a birth certificate.

Web 2.0 is infested with cybercrime – dark deeds of every description from identity theft to click fraud this all can be avoided or atleast reduced by digital identities.

#### *2. Semantic Web*

Tim Berners-Lee coined the term for a web of data that can be processed by machines.

The semantic web will help teach the computer what the data means and that will evolve artificial intelligence which can utilise that information.

The core idea is to create a spiderweb of knowledge across the internet which will help it to understand the meaning of words to generate, share, and connect content through search and analysis.

#### *3. Artificial Intelligence (AI)*

AI will allow websites to filter and present users the best data possible.

Example: A group of people may get together and give positive ratings to an undeserving movie, boosting their ratings up.

Artificial intelligence can learn how to separate the good from the bad and gives us reliable data.

#### *4. 3D Graphics*

Web 3.0 is going to change the future of the internet developing from the simple 2D web into a more realistic three-dimensional cyberworld.

The three-dimensional design is being used extensively in websites and services in Web 3.0 such as online games, e-commerce, real-estate industry, etc.

### 5. Ubiquitous

Ubiquitous means the idea of existing or being everywhere, especially at the same time i.e., omnipresent.

Development of mobile devices and internet access will make the Web 3.0 experience available anywhere at any time.

The internet will no longer only be on your desktop like with Web 1.0, or your smartphone, like Web 2.0, it will be omnipresent.

Web 3.0 may as well be called the web of everything and everywhere, as most things around you are connected online with Internet of Things.

#### Advantages

- Increased information linking: Semantic web will help in the connectivity of online data.
- Efficient searching.
- Better marketing.
- More efficient web browsing.
- Effective communication.

#### Disadvantages

- Less advanced devices will not be able to handle Web 3.0.
- Web 1.0 websites will seem much more obsolete.
- It can be very complicated for newcomers to understand.

Notes:

- Web 3.0, as a decentralised internet that runs on a public blockchain is the next version of the internet, where services will run on blockchain. It is also used for cryptocurrency transactions.
- It will be permissionless and democratic. For instance: Twitter will not be able to censor posts and Facebook will not be able to maintain a database of billions of users that can be potentially used to influence elections.
- All data will be interconnected in a decentralised way, unlike the current generation of the internet (Web 2.0), where data is mostly stored in centralised repositories.
- Indian TikTok rival Chingari recently shifted from a Web 2.0 model of incentives for content creators to a Web 3.0 model. The start-up raised over $19 million in October 2021, that will help it build its token called '$GARI' on the Solana blockchain.
- A range of Indian start-ups like Biconomy, Polygon, EPNS, Persistence, and Vauld are working to put together the technological building blocks to make Web 3.0's mass adoption a reality. Polygon, crossed a market capitalisation of $10 billion recently.
- By one estimate, Web 3.0 can help India contribute an additional $1.1 trillion of economic growth to its GDP over the next 11 years.
- Note: The most recent example of Web 3.0 are the NFTs or non-fungible tokens.

## Web 5.0

Recently, **former Twitter CEO Jack Dorsey announced his vision** for a new decentralised web platform that is being called Web 5.0.

Web 5.0 is aimed at "**building an extra decentralised web** that puts **you in control of your data and identity**" that is return of "**ownership of data and identity to individuals**".

- It is being developed by Dorsey's Bitcoin business unit "**The Block Head" (TBH).**
- According to TBH, "**The web democratised the exchange of information, but it's missing a key layer: identity. Today, identity and personal data have become the property of third parties.**"
- This is what is the **purpose of Web 5.0 giving the identity ownership to an individual who owns it rather than third parties.**
- Web 5.0 is **Web 2.0 plus Web 3.0** that will **allow users** to '**own their identity**' on the Internet and 'control their data'.

Note: Web 3.0 is not truly decentralised or owned by its users, but is instead controlled by various "venture capitalists and limited partners".

- **Web 5.0 (Intelligent web / symbiotic web)** also called the **sensory and emotive Web**, is designed to develop computers that interact with human beings.
- This **relationship will become a daily habit for many people** in the coming future with the augment of Web 5.0.
- Web 5.0 will see **applications able to interpret** information on **more complex levels, emotionally as well as logically.**
- **It will focus on the individual**, perhaps allowing a website to convey a different experience for each different person.
- **It could perceive the emotions of an individual** and respond appropriately, and it could detect subtleties that enable more powerful interactions.

**Cases for Web 5.0:** There are two use cases that Web 5.0 will change things in the future –

1. **Changes the "Control of Identity":** An individual can switch apps whenever she wants, taking her social persona with her. E.g. Person detail on various social media.
2. **Gives users control over their own data:** An individual can keep his data in his decentralised web node. E.g. Music on various apps will identify your choices without feeding information.

(Refer **Infographic – Web 1.0 vs Web 2.0 vs Web 3.0 vs Web 4.0 vs Web 5.0**)

# Web 1.0 vs Web 2.0 vs Web 3.0 vs Web 4.0 vs Web 5.0

## WEB 1.0

- Web 1.0 was the initial version of the internet, establishing a worldwide network and setting the foundation for digital communication and information exchange.
- It represented the first generation of the global digital communications network and was often referred to as the "read-only" Internet.
- Web 1.0 was comparable to a digital encyclopedia, featuring interconnected web pages using hyperlinks. However, it lacked the interactive elements found in today's internet, leading to its nickname as the "read-only" web.
- Web 1.0 is characterized by several defining elements, which include:
  - static pages
  - usage of HTML 3.2 elements like frames and tables
  - HTML forms that are sent via email
  - content is retrieved from the server's file system rather than a relational database management system
  - utilization of GIF buttons and graphics

## WEB 2.0

- The next stage after Web 1.0 was the "read and write" Internet, which enabled users to communicate with servers and other users, giving rise to the social web.
- Web 2.0 shifted the focus from a few content creators to a larger community generating a vast amount of content.
- It emphasized user-generated content (UGC), ease of use, participation, interactivity, and compatibility with different devices and systems.
- Web 2.0 prioritized the end user's experience, leading to the emergence of communities, collaborations, dialogue, and social media as primary ways of interacting with the web.
- The social web of Web 2.0 incorporated various tools and platforms, such as podcasting, social media, tagging, blogging, commenting, and voting, enabling hyper-interactive sharing of opinions, daily experiences, and perspectives.
- However, traditional Web 2.0 applications had limitations in terms of how they functioned, where user requests were sent to the server, and the server responded with the webpage, posing some challenges.

## WEB 3.0

- Web 3.0 refers to the next generation of the internet, characterized as a "read-write-execute" web with decentralization as its foundation.
- It is considered the future of the internet, providing a space where users operate on decentralized and nearly anonymous platforms, moving away from the influence of tech giants.
- Web 3.0 was initially called the Semantic Web, envisioned by Tim Berners-Lee as a more autonomous, intelligent, and open internet.
- The original concept involved leveraging AI and ML to process content like "global brain," connecting data contextually and conceptually.
- Key elements defining Web 3.0 include the improvement of web technologies for content creation, sharing, and connection based on comprehension rather than keywords.
- It integrates AI and ML, enables connectivity among applications and devices through the Internet of Things, incorporates 3D graphics, and promotes interactivity without intermediaries.
- Web 3.0 aims to enable participation without requiring authorization from governing bodies.
- The objective is to create a more intelligent, interconnected, and user-centric internet experience.
- Web 3.0 is still under development, seeking to overcome limitations of previous iterations and shape a more advanced and inclusive internet landscape.

## WEB 4.0

- Web 4.0, known as the Symbiotic Web, emphasizes the symbiotic interaction between humans and machines.
- It enables autonomous, proactive, and content-exploring systems driven by self-learning agents and advanced semantics.
- The Symbiotic Web leverages automation, deep learning models, and natural language processing to generate insights and support decision-making.
- It facilitates the integration of hardware, software, and data, offering personalized experiences and expanding possibilities with virtual reality (VR) and augmented reality (AR) applications.
- Web 4.0 provides businesses with opportunities to deliver personalized experiences, enhance efficiency through AI-driven automation, create new products and revenue streams, and engage customers in innovative ways.
- Future possibilities of Web 4.0 include more natural interactions with autonomous agents, advanced AI systems, powerful hardware and software, and immersive VR and AR experiences.
- Web 4.0 represents an exciting evolution that will revolutionize human-machine interaction and unlock new potentials.

## WEB 5.0

- Web 5.0, developed by Dorsey's Bitcoin business unit, aims to create a decentralized web that gives users control over their data and identity.
- It combines the concepts of Web 2.0 and Web 3.0, allowing users to own their online identity and have control over their data.
- Web 5.0 aims to overcome limitations in previous versions and create an internet free from censorship and major outages.
- Unlike Web 3.0, which is not fully decentralized or user-owned and is controlled by venture capitalists and limited partners, Web 5.0 seeks to empower users.
- It envisions a platform that incorporates emotional intelligence, fostering a deeper connection between humans and computers.
- Web 5.0 intends to implement features like decentralized identity control, data ownership, and improved privacy through blockchain technology.
- While still in development, the goal of Web 5.0 is to create a more efficient, transparent, and user-centric internet experience.

## 11.16 COMPUTER SECURITY

'The protection of data against accidental or intentional destruction, disclosure or modification is termed as Data or Information Security'.

All the technological safeguards and managerial procedures applicable to computer hardware, software and data is included under computer data security. It ensures that organisational and individual privacy are protected. Various types of computer security tools used.

### 11.16.1 Firewalls

A device that guards the entrance to a private network and keeps out unauthorised or unwanted traffic is termed as Firewall. It can be implemented in both hardware and software, or a combination of both. Firewalls are frequently deployed to prevent unauthorised Internet users from accessing private networks connected to the Internet, especially intranets. Firewalls, as a security policy, distinguished 'good' traffic from 'bad' traffic.

**IMPORTANT POINTS**

**TCP is developed:** Vinton Cerf and Robert Kahn designed TCP during 1973.

**First commercial network:** In 1974, the commercial version of ARPANET, known to be Telnet, was introduced and many considered it to be the first Internet Service Provider (ISP).

**Ethernet is conceived:** Bob Metcalfe developed the idea of Ethernet in 1973.

**HTML:** Tim Berners-Lee developed HTML in 1990. It made a huge contribution to how we navigate and view the Internet today.

**USB Dialers:** Various Internet Service Providers like BSNL, Reliance and Tata, etc., are providing their services through USB Dialers. A pen drive-type small device, with a SIM card fitted in it, employs CDMA technology and offers a good speed. It may be connected to any Laptop or Desktop for Internet access.

### 11.16.2 Rootkit

A rootkit is designed to conceal the compromise of a computer's security. As a set of programmes, it works to subvert control of an operating system from its legitimate operators. It may include the replacements for system; binaries are included in rootkit for immobilising the genuine user during the detection of intruder presence on the system by looking at process tables.

Hacker: A 'clever programmer' or 'someone who tries to break into computer systems' is known to be a Hacker. A hacker can be an expert programmer. There are two types of Hackers: (1) Ethical Hacker (2) Malicious Hacker.

Note: Malicious Hacker, known as cracker, refers to those who break into computers without authorisation.

## 11.17 COMMON SECURITY BREACH METHODS

### 11.17.1 Computer Virus

Computer virus (a software programme) is developed by a programmer to infect other programmes. The viruses adversely affect the computer system in the following manner: Destructs file allocation table (FAT); Erases specific programme and data on discs; Alters contents of files; Suppresses execution of RAM; Destroys part of the programme/data held on disc *via* bad sectors creation; Reduces free space on disc; Formats discs or tracks on discs in a different way.

### 11.17.2 Worm

A WORM is also a self-replicating programme, just like the virus with major difference of not creating copies of itself on one system. It propagates through computer network.

### 11.17.3 Trojan Horses

A Trojan horse is a malware programme, which seems to mislead the users by doing one thing, but in reality, another thing is being done and is used in the setting up of a rear door into the system, thereby enabling the intruder in getting access to users' personal information afterwards.

### 11.17.4 Spoofing Attack (Phishing)

A programme, system, or website successfully masquerading as another by falsifying data and thereby being treated as a trusted system by a user or another programme, is included in spoofing attack. It is aimed

in deceiving the systems, programmes or users through disclosing confidential data, such as user names and passwords, to the hackers.

### 11.17.5 Spyware

It is a software programme that gathers personal information secretly and sends it from the computer without the user's knowledge through the Internet connection. Adware software programme is an example of a spyware.

**MALWARE OR MALICIOUS SOFTWARE**

Malware is any programme or file that is harmful to a computer user. It includes computer viruses, worms, Trojan horses and spyware. They create various types of problems like stealing of data, encrypting or deleting sensitive data, altering or hijacking core-computing functions and they start to monitor computer without permission.

**IMPORTANT POINTS**

- **Wikipedia** was introduced by Jimmy Wales on 15 January 2001.
- **YouTube**, launched by Javed Karim, Chad Hurley, Steve Chen in 15 February 2005.
- The **Pandora Internet radio service** was launched on 25 August 2005. Bing was launched by Microsoft as a search engine on 3 June 2009.
- **Orkut** was launched officially on 24 January 2004 by Google engineer Orkut Buyukkokten.
- **Google:** It was first incorporated as a privately held company on 4 September 1998. **Founders**: Sergey Brin and Larry Page.
- **Yahoo:** (Yet Another Hierarchical Officious Oracle) started in Jan 1994 by Jerry Yang and David Fillo.
- Vinton Cerf and Robert Kahn invented **TCP/IP protocol** in the 1970s and Ray Tomlinson introduced network email in 1972.

## 11.18 GLOBAL INTERNET GOVERNANCE

The way in which the Internet is managed is known as Internet governance.

### 11.18.1 International Telecommunication Union (ITU)

The International Telecommunication Union (ITU) is the United Nations specialised agency, which was originally founded as the International Telegraph Union in 1865. Its headquarters is at Geneva, Switzerland. It holds responsibilities, which are concerned with information and communication technologies. The ITU not only manages the usage of shared radio spectrum globally but also undertakes the promotion of worldwide collaboration in the assignment of satellite orbits. It significantly performs on infrastructure improvisation in respect of telecommunication towards development and coordination of worldwide technical standards.

*The ITU consists of three sectors:*

- **Radio Communication (ITU-R)** – ensuring effective, fair and balanced usage of the radio frequency (RF) spectrum.
- **Telecommunication Standardisation (ITU-T)** – prepares the standardising telecommunication operations recommendations worldwide.
- **Telecommunication Development (ITU-D)** – aids countries in development and maintenance of internal communication operations.

There are **193 ITU Member states, consisting of all UN member states excluding the Republic of Palau, plus the Vatican City.**

**ITU membership is open to only UN members,** which may join as Member States, **and also to private organisations such as equipment manufacturers, carriers, funding bodies, organisations of research and development and international and regional telecommunication organisations, which may join as nonvoting Sector Members.**

*Functions*

- The ITU defines and circulates rules and principles significant to electronic communication and broadcasting technologies of all types such as radio, television, satellite, telephone and the Internet.
- The organisation carries out working parties, study groups and meetings for addressing present and future issues and for resolving disputes. Every four years, the ITU arranges and holds an exhibition and forum termed as the **'Global TELECOM'**.
- Another significant feature of the ITU's mandate is to assist developing countries for establishing and developing telecommunication systems of their own.

- Even though the ITU recommendations are non-binding, the majority countries adhere to them for keeping up a useful environment of international electronic communication.

Note: The International Telecommunication Union (ITU) has declared that it will set up its South Asia Area Office and Technology Innovation Centre at New Delhi.

## 11.18.2 ICANN

It stands for Internet Corporation for Assigned Names and Numbers and plays an important role in the global Internet's system coordination of sole identifiers, particularly, ensuring the operation in a secure and stable way. It was formed in 1998 as a non-profit partnership of people from all over the world to secure Internet. ICANN develops policy on the Internet's unique identifiers but it does not control content on the Internet.

ICANN is an organisation incorporated under the law of the State of California (USA). ICANN is accountable by the judicial system, i.e., ICANN can be taken to court. ICANN has a board of directors, who are legally responsible for their duties under this law. It is a non-profit public benefit corporation.

Global internet body, Internet Corporation for Assigned Names and Numbers (ICANN) and Indian IT industry body NASSCOM to develop identifier technology that can be used for managing devices and infrastructure using the internet.

It will first focus on updating the Internet of Things (IoT) devices using domain name system (DNS) even in the situation when the manufacturer or supplier has closed down the business.

This collaboration provides a structure to jointly identify research projects, particularly in new technologies related to the internet's system of unique identifiers.

**FOUR MAJOR FUNCTIONS OF ICANN**

- **Companies' approval** that can become recognised registrars for domain names.
- **Decision making** in regard to the new Top-level Domains (TLDs) additions to the Root system.
- **Manage technical factors** for maintaining widespread connectivity.
- **Forming a Uniform Domain Name Dispute Resolution Policy (UDRP)** for contending domain names.

### 11.18.2.1 Domain Name System (DNS)

The DNS is an arranged disseminated system for naming computers, services or any resource, which is linked to the Internet or any private network. The DNS is used for the translation of simply memorised domain names into the IP addresses in the numerical form. The DNS is an essential component of the functionality of the Internet, as it provides a worldwide, distributed keyword-based redirection service.

#### *Domain Name*

A domain name, such as 'abc.com', works as a string of classification, for defining the administrative autonomy, authority or control area on the Internet. These are assigned according to its existing rules and procedures and any name, which is DNS registered is a domain name. Normally, it represents an Internet Protocol resource and is used for the naming and addressing purpose and in the context of networking.

### 11.18.2.2 What is the Issue?

Though there is no sole owner of Internet, it is mainly controlled by USA because of ICANN; (Recently, the control over ICANN was renounced by USA) but other countries are advocating oversight of United Nations for Internet Governance.

As a result of recent surveillance programmes of USA, the right to control Internet available in the respective country is being demanded by many countries, which includes India (for security purpose). On the other hand, global powers like Russia and China want Internet controls as a demonstration of their super power.

### 11.18.2.3 Electronic Surveillance Disclosures

- Electronic surveillance by USA created much buzz across the world.
- Brazilian President Dilma Rousseff, during her address in the United Nation General Assembly, complained about supposed surveillance and asked the UN for taking a leading role in an attempt to regulate the conduct of states in respect of new 'multilateral mechanisms for the worldwide network'.

#### 11.18.2.4 USA's View

- Freedom of Internet is one of the columns of foreign policy of USA.
- Internet freedom will be defended at any cost (i.e., by controlling and keeping the Internet rights only with USA).
- The present proposal of transferring Internet control to United Nations would provide UN with greater power.
- If the Internet control will be handed over to UN, then it will direct to greater suppression and a spectacular anonymity reduction.

#### 11.18.2.5 The Real Debate

- The real debate is whether to possess an open Internet globally or a national Intranets patchwork. It is also being discussed that UN be given Internet control and the individual nations be allowed the Internet addresses management in their own areas. At present, there are two groups, the demand of one group is multilateral platform consisting of India, Russia and China and the other group's demand is multi-stakeholder platform consisting of USA.
  Countries are demanding more sovereign control over web addresses.
- The threat expected is that once every country is allowed to manage their own Internet address books, sites seen as troublesome by the governments could be easily and silently eliminated by removing them from the index and making them permanently inaccessible to the outside world.
- Already, the governments at their discretions are having powerful tools with them, such as the regulatory authorities over telecommunications companies such as China's control over the Internet that gives it an edge for paralysing the Internet services when it wants. Then why is there a need of an extra control on Internet?

#### 11.18.2.6 Why India is Worried?

- India was authorised to contain root servers (computers through which all Internet data originating or coming to a particular country passes through) but their management was not given to the country. No servers' control and management is allowed to India.
- This type of policy is of no use to the country. For the country's security reasons, it requires their control.
- India is concerned on the China, Russia and USA closeness over Internet governance.
- India believes that these countries would formulate a strategy, which will the ultimately be forced upon other countries. Hence, the country is pressing its demands and voice in order to meet all the country's problems before the formulation of any strategy.
- India is inclined towards a pre-dominate joint approach (each country be provided a power to speak over this issue) on Internet governance issues rather than multi-stakeholder approach (only few countries are authorised to speak), which is mostly followed by the West.
- India has the world's second largest number of Internet users, with nearly 48 crore, just after China, which is 56 crore.

### 11.19 INTERNET OF THINGS (IoT)

- IoT is the network of physical objects, which is accessed through the Internet, as defined by technology analysts and visionaries, comprising of embedded technology to interact with internal states or the external environment.
- IoT is the way of connecting new places like transportation systems, manufacturing floors, energy grids and healthcare facilities through the Internet. Through the help of this technology, an object can represent itself digitally and can be controlled from anywhere easily. This connectivity will bring more ways to increase efficiency and improve safety and security.
- Through the help of the IoT, all objects, animals or people are provided with unique identifiers and easily transfer data over a network without requiring any interaction, be it human-to-human or human-to-computer. IoT has evolved from the convergence of Internet, wireless technologies and micro-electromechanical system (MEMS).
- IoT has a broad scope; a heart patient can monitor his/her heart easily; farm animals can be easily tracked with the help of biochip transponder;

an automobile that has built-in sensors can alert driver when tire pressure is low. Any natural or man-made objects that can be assigned by an IP address have the ability to transfer data over a network. Nowadays, IoT has been most closely associated with machine-to-machine (M2M) communication and various other uses like power, oil and gas utilities.

### *India's first 'Internet of Things' policy: One step closer to Smart and Digital India*

Department of Electronics and Information Technology (DeitY) now called as the Ministry of Electronics and Information Technology had drafted India's first 'Internet of Things Policy'.

### *India's First IoT policy*

Two major efforts taken by the Government of India, which will lead to a rapid growth of IoT industry are Smart Cities Project and Digital India Programme. These two major initiatives by the GoI will definitely boost the IoT industry and pave the way forward for it.

### *What the policy had in-store for the IoT industry?*

- As part of this policy, GoI will fund research and development for specific applications in IoT. Also, DeitY plans to initiate an innovative project named 'International IoT Research Collaboration scheme (IIRC)' to get investments from private sector for research and development.
- In order to support the growth and boost investment in IoT, government will promote venture funds, which provide support to organisations in IoT-related domains like memory, processors, sensors, low-power devices and solar electronics.
- This policy will be supporting high-quality manufacturing of IoT devices in India without affecting the environment. 100 per cent duty benefit will be available on raw materials imported for manufacturing IoT devices, thereby helping organisations to maintain their expenses.
- Also, domestically purchased raw materials will get excise and CST reimbursement. These benefits will lower the costs of IoT devices on the whole, benefitting the organisations that are manufacturing as well as using them.
- Development of human resource is important for any industry to be successful and with this objective, DeitY will be responsible for creating an IoT Education and Awareness programme with the aim to develop skillsets required for IoT at various levels to allow smooth functioning of the industry.

### *India's first IoT platform*

- Home-grown technology and IoT company Smartron unveiled 'tronX' – an Artificial Intelligence (AI)-powered IoT platform that would help make users' daily life easier and smarter. Terming it as one of the first global technologies being developed in India, the company said 'tronX' is an intelligent ecosystem that helps connect a range of devices.
- Built on the world of 'Internet of Trons', the ecosystem allows instant access to profile, data, content, services, community and other IoT devices whether you are at home, in the car or at the office. 'Smartron has been working for more than two years on creating a new connected ecosystem fuelled by AI-powered "IoT" and "tronX" is at the core of this brave new world'.
- To begin with, Smartron announced four verticals that are in the works at its research and development facility and already have built-in capabilities that integrate in our lives: 'tronX Personal', 'tronX Health', 'tronX Home' and 'tronX Infra'. 'tronX Personal' offers personalised entertainment, travel, shopping, financial, health, event, communication and collaboration experiences across devices and contexts.
- With 'tronX Health', the system monitors and manages medical history, insurance data and offers intuitive and preventive solutions from a range of partners, who are already on board. 'tronX Home' helps control locking mechanisms, security updates, home appliances, services like water, electricity and payment modules for these services, all available through a Voice Activated Assistant.
- 'tronX Infra' is Smartron's B2B vertical, offering an AI-assisted system that covers a range of monitoring and management services, thus increasing productivity and security for enterprises. Smartron was founded with a vision to build India's first true global OEM brand to

revolutionise the country's ecosystem and create experiences that are at par with global innovations. [Refer **Infographic – IoT (Internet of Things)**]

## 11.20 NET NEUTRALITY AND INTERNET FAST LANES: THE DEBATE

### 11.20.1 Net Neutrality

Net Neutrality is also called as network neutrality or Internet neutrality is the guiding principle of equality that Internet service providers and governments should follow. It implies that all Internet data should be given equal treatment with no discrimination or differential charges for users, content, site, platform, application, type of attached files or mode of communication.

In simple words, it implies no restriction to access any type of content on the web, no restrictions on downloads or uploads, and no restrictions on communication methods (email, chat, etc.). It also concludes that access will not be blocked, slowed down or sped up on the basis of owner of the access point(s).

### 11.20.2 Why is Net Neutrality Important?

**Growth:** Since its creation by Sir Tim Berners-Lee (in 1991), it became the chief reason of the phenomenal rate of web growth.

- **Creativity:** Creativity, innovation and unbridled inventiveness have given us Wikipedia, YouTube, Google, Torrents, the Internet Movie Database, and many more.
- **Communication:** It is because of this net neutrality we enjoy the access and ability to communicate with people on a personal basis, government leaders, business owners, celebrities, work colleagues, medical personnel, family, etc., with no restrictions.

### 11.20.3 Issue

- The US Federal Communications Commission recently jeopardised the prospects for 'net neutrality', a principle requiring non-discrimination by Internet service providers between their client websites, when it voted in favour of a proposal to allow ISPs to charge higher fees to those who seek to deliver higher-quality content in the US.
- This raised a debate of Internet Governance and Free access of Internet by the users.

**KEY POINTS**

- Net neutrality means that users get unrestricted access to Internet traffic without any discrimination.
- In its real sense, net neutrality is 'Freedom of Speech and Expression without partiality'.
- In recent past, there have been violations of net neutrality by certain governments and companies.
- The Federal Communications Commission (FCC) enacted the Open Internet Order in 2010 in order to prevent large telecommunication firms from stifling competition and innovation online.
- The FCC, in its order, stated that net neutrality rules were intended to 'preserve the Internet as an open platform, enabling consumer choice, freedom of expression, end-user control, competition, and the freedom to innovate without permission'.
- Few countries like Chile have enacted laws to protect net neutrality.
- In India, there is no net neutrality law and it is not regulated by government. India is yet to come up with a transparent and impartial law.

### 11.20.4 Telecom Commission Approved TRAI Recommendations on Net Neutrality

- **Telecom Commission (a group within India's Department of Telecom)** has agreed to the recommendations given by **TRAI** on net neutrality.
- The move plans in ensuring that all web traffic is treated in a fair manner, and that Internet service providers won't obstruct, choke or favour any material or services (with a few reasonable exceptions).

***The rules***

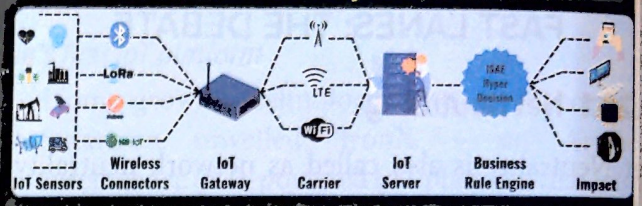
- According to the country's net neutrality rules, mobile operators, Internet providers and social-media and Internet companies cannot indulge in, or ask for, special treatment as from now there will be prohibition on interference of any kind in the content treatment, consisting of practices such as **jamming, mortifying, slowing down or giving way differential speeds or treatment to any content.**

# IoT (Internet of Things) IoT

## What is Internet of Things?

The Internet of Things is a system made up of physical devices connected by the internet and capable of accumulating and sharing data across a network. While the platforms used to develop IoT devices can differ, they all have the same core components in common when it comes to their contribution.

## IoT Examples




## Components of IoT

1) IoT Sensors
2) Connectivity/Network
3) Cloud
4) Hyper Decision Framework
5) User Interface

## IoT Growth

- In 2015, small business and mid-sized companies did not have IoT technology as a priority. Fast-forward to today, and many of them now rely on devices for handling day-to-day business.
- 7 Billion devices were connecting to the internet in 2018, with that numbers were expected to reach anywhere from 10 to 14 billion by 2020.
- Researchers estimated that the average person will have at least 4 connected devices by 2021.
- Experts now expect the value of the IoT markets to exceed 1.5 trillion by the year 2025.

# How IoT Works?

1

The Data needs to be sent to cloud to be analyzed, but it needs a way to get there.

To ensure the data security protocols such as Bluetooth, LORA, Zigbee, etc. are used.

2

## Data Ingestion

IoT devices and sensors gather data from the surrounding environment, ranging from basic measurements such as temperature and humidity to more complex information like full video feeds. The amount of data produced by IoT devices every day is staggering, reaching nearly quintillions of data bytes.

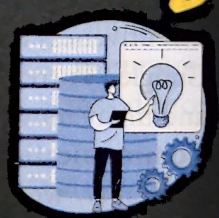
## Data Tramission

The data collected by IoT devices is sent to the cloud using telemetry devices called gateways. These gateways employ a combination of cellular and satellite communication to transmit the data.

One can make intelligent business decisions based on the insights and predictions generated from the data.

5

3



## Data Processing

Once the data arrives in the cloud, it is processed by an IoT platform. The processing may involve simple operations like checking if the temperature falls within the acceptable range, or it can be more intricate, such as applying computer vision algorithms to identify objects in a video feed.

## Data Analysis & Prediction

Data analytics utilizes historical data to derive actionable insights, enabling the prediction of future events. For instance, by analyzing data, it becomes possible to anticipate potential machinery malfunctions.

4

## Data Visualization

Processed data is converted into useful information for users through alert notifications via email, text messages, or notifications. Users can also utilize an application or interface to proactively monitor and engage with the system.

- Any efforts to build **'zero rated platforms' have now been stopped.** Zero-rated platforms, which had earlier been attempted (by companies such as Airtel and Facebook) but banned, offer free only a certain category of services and websites, thus forming paid layers and stifling competition and modernism.
- Under net neutrality, **access of online contents is not restricted and non-discriminatory.** The only exceptions are fresh and rising services such as **autonomous driving, tele-medicine or remote-diagnostic services, which may need focussed Internet lanes and faster-than-normal speeds.**
- A **committee will look after** into the probable exceptions for 'critical services' which will also be defined considering the basic doctrine of net neutrality.

## 11.21 NETWORK

A computer network or data network is as a telecommunication network allowing computers to transfer data in and out. In computer networks, networking devices exchange data with each other using a data link. The connections between nodes are established using either a cable media or wireless media. The best-known computer network is the Internet.

- Various kinds of computer networks can be characterised by their size and purpose. The geographical area occupied and the number of computers forming the network express the size of network. Anything ranging from a handful of devices to millions of devices spread across the whole globe can be covered under network. Here are few networks based on size:
  1. Personal area network, or PAN
  2. Local area network, or LAN
  3. Metropolitan area network, or MAN
  4. Wide area network, or WAN

### 11.21.1 Personal Area Network (PAN)

- Personal area network or PAN implies a network covering a very small area; for example, a small room. Bluetooth is the best-known wireless PAN network technology, while the most popular wired PAN is USB. The wireless headset, printer or the smartphones may not appear as components in a network, but they definitely communicate with each other. Many peripheral devices act as computers in their own right.
- A PAN interconnects information technology devices within the range of an individual person.
- It usually works within a range of 10 metres.
- The concept of a PAN was first developed by Thomas Zimmerman.
- Examples: Bluetooth, NFC, Share-it, Xender.

### 11.21.2 Local Area Network (LAN)

- The network that operates within a limited physical area is termed as LAN. It enables linking of several computers within a building, companies, offices and factories in order to share resources and information in close proximity, e.g., Wi-Fi, Hotspot.
  1. Two or more PCs can form a LAN to share files, folders, printers, applications and other devices.
  2. Connections use coaxial or CAT 5 cables.
  3. Since there are short distances, the errors and noises are minimum.
  4. Data is transferred at the rate of 10–100 mbps.
  5. Distinction on their transmission media and topology.
  6. A computer lab in a school, Wi-Fi are common examples of LAN.
  7. Range is nearly 1 km.

### 11.21.3 Metropolitan Area Network (MAN)

- MAN is larger than LAN but smaller than WAN, e.g., Wi-Max, FM, STD code of a city (011-for Delhi).
  1. Designed to extend over a large area.
  2. Resources are shared by connecting number of LANs forming larger network.
  3. The usual range is up to 5–50 km.
  4. The owner can be an organisation or an individual.
  5. Compared to LAN, the rate of data transfer is low.
  6. Organisation with different branches located in the city.

### 11.21.4 Wide Area Network (WAN)

- It covers a wider area, larger than LAN and MAN. It can have multiple ranges like a network connecting multiple buildings on a corporate or college campus to satellite links connecting offices in different countries. The Internet is one of the most popular WAN. In true sense, it represents a collection of other networks, including other LANs and WANs, hence, the name is derived.
- WANs can be wired (using fibre-optic cable) or wireless. A wireless WAN might use microwave or infrared (IR) transmission technology. Even a satellite can be used for transmission. To save money, an organisation may opt for wireless technology or lease lines from a third party. E.g., Internet, AM, +91 (Nation Code).
  1. Includes country and worldwide network with multiple LANs and MANs.
  2. The geographical range is the most distinguishing feature.
  3. Uses satellites and microwave relays.
  4. The ISP provider guides the data transfer rate, which varies over the location.

## 11.22 VARIOUS MODES OF NETWORK CONNECTION

### 11.22.1 Bluetooth

- Bluetooth standard derives its name from a tenth century Scandinavian king, **Harald Bluetooth**. Modern Bluetooth technology was developed by Jaap Haartsen and Sven Mattis-son in 1994, working at Ericcson in Sweden. In 1998, the original group of Promoter companies – Ericsson, Intel, Nokia, Toshiba and IBM – came together to form the Bluetooth Special Interest Group (SIG).
- A wireless technology standard (i.e., Bluetooth) enables data exchange over small distances (using UHF short-wavelength **radio waves** ranging from **2.4 to 2.485** GHz) through mobile and fixed devices, thereby forming a kind of Personal Area Networks (PANs).
- A headset or watch, as a Bluetooth product, has a tiny computer chip with a Bluetooth radio and software, which makes the connection easy to connect. The two Bluetooth devices should be paired while communicating to each other.
- Bluetooth is a packet-based protocol with a **master-slave structure (Piconet)**, that is, a master Bluetooth device communicates with seven devices maximum in a piconet (an ad-hoc computer network using Bluetooth technology); however, all the devices do not reach this maximum.
- There are two versions of Bluetooth (**Table 11.2**), which are differentiated on the basis of data sharing distance and power consumption.

**TABLE 11.2 Bluetooth Versions**

| Bluetooth (Version) | Maximum Speed | Data Sharing Distance |
|---|---|---|
| 4.0 | 25 Mbps | 200 feet (60.96 m) |
| 5.0 | 50 Mbps | 800 feet (243.84 m) |

### 11.22.2 Wi-Fi Direct

Wi-Fi direct is the chief competitor of Bluetooth 4.0. Wi-Fi Direct and Bluetooth, both operate at **2.4-gigahertz frequency band.**

***Comparison of Bluetooth 4.0 and Wi-Fi Direct:***

- The speeds offered by **Wi-Fi Direct are up to 250 Mbps** while Bluetooth 4.0 lags behind at a paltry-seeming 25 Mbps.
- The stated maximum distance of **Wi-Fi Direct is more than 600 feet** while Bluetooth 4.0 has 200 feet.
- Only the battery life is less in the case of Wi-Fi Direct in comparison to Bluetooth 4.0.
- Bluetooth 4.0 uses 128-bit encryption to protect your data while transmitting data between devices. On the other hand, the Wi-Fi Direct uses 256-bit encryption. Hence, Bluetooth 4.0 is remarkably secure than Wi-Fi direct. All Wi-Fi Direct operates in 2.4 GHz frequency band.

Note: Share-it and Xender types of application (App) connect through Wi-Fi direct.

### 11.22.3 Cordless Phone

Cordless phone (or portable phone) serves as a replacement of the handset cord with a radio link,

which is connected with base station and also connected with a fixed telephone line. This technology is based on **radio waves** and **amplitude modulation.** In 1994, bandwidth of the cordless phone was 900 megahertz but today it is **2.45 gigahertz.** One phone is connected with the other when both are located in the radio radar. Today cordless telephones use PHS (Personal Handy-phone System) and DECT ((Digital Enhanced Cordless Telecommunications).

### 11.22.4 Wi-Fi

Wi-Fi stand as Wireless Fidelity. This type of technology allows electronic devices to connect wireless LAN (Local Area Network). **Vic Hayes** is called the father of Wi-Fi. He created Wi-Fi 802.11 standard in 1997. It is **radio wave** based technology of bandwidth **2.45-5 gigahertz.** It is carried to maximum distance of **100 metres** and a speed of 11 megabytes per second (802.11b standard) – 1.3 gigabytes per second (802.11ac standard). There are various standards of Wi-Fi developed – 802.11b, 802.11a, 802.11g, 802.11n and 802.11ac.

### Wi-max (Worldwide Interoperability for Microwave Access)

Wi-max is the hottest broadband wireless technology. It is expected to provide services to residential and enterprise customers in an economical way. **Its characteristics are similar to Wi-Fi but it can accommodate larger distances and greater number of users.** It carries MAN network bandwidth of 1 gigabits per second. It is a long-term system covering many kilometres in the cases of Internet connection. It needs a base station where service is provided in greater number and carries the **microwave access.** Initially, it provided 30–40 megabits per second but from 2011 it is providing up to **1 gigabits per second**.

### 11.22.6 NFC (Near Field Communication)

Near Field Communication (NFC) represents a set of **short-range wireless technologies** that typically requires a distance of **4 cm or less to initiate a connection.** This network carries **point-to-point range of up to 20 cm** and operates on **13.56 megahertz frequency** at rates ranging from **106–424 kilobits per second** (whereas Bluetooth 4.0 is 25 megabits per second). NFC always works on initiator and target principle wherein the initiator actively generates an **RFID** field that can power a passive target. Firstly, Sony was approved for NFC but now so many mobile companies are interested about NFC.

Note: In 1983, the first patent with the abbreviation 'RFID' (Radio frequency identification) was granted to Charles Walton.

#### *Comparison between NFC and Bluetooth*

Both, NFC and Bluetooth represent short-range communication technologies, which are available on mobile phones. NFC does not require pairing and operates at slower speeds (as compared to Bluetooth), but consumes far less power. NFC needs less time to set up than standard Bluetooth; however, the transfer rate is slower than Bluetooth. The connection between two NFC devices is automatically established in less than 0.1 second, rather than Bluetooth *via* manual configurations to identify devices.

### 11.22.7 Li-Fi (Light Fidelity)/Visible Light Communication (VLC)

University of Edinburgh Professor, **Harald Haas** coined the term Li-Fi in 2011. His invention was demonstrated using an ordinary table lamp, which successfully transmitted data at speeds exceeding **10 megabits per second** using **light waves** from LED light bulbs to a computer located below the lamp. He periodically blocked the beam of light, which caused the connection to drop. This proved that the light bulb was the source of the data stream. The LED bulb will hold a microchip that processes the data. We can manipulate the light intensity to send data by tiny changes in amplitude. The visible spectrum of light, a part of the electromagnetic spectrum (that is still not greatly utilised) is used by this technology. The inventor of Li-Fi, Harald Haas called the light used to transmit the data as **D-light**. In future, data for laptops, smartphones and tablets can be transmitted through the light in a room by using Li-Fi. Li-Fi is a **Visible Light Communications (VLC)** system running wireless communications travelling at very high speeds, boasting speeds of **up to 224 gigabits per second.** Li-Fi is many times better than Wi-Fi (**Table 11.3**).

**TABLE 11.3 Difference between Wi-Fi and Li-Fi**

| S. No. | Wi-Fi | Li-Fi |
|---|---|---|
| 1. | Wi-Fi transmits data over the radio waves. (Note: Both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum.) | Li-Fi transmits data over the visible light and some Li-Fi technologies transfer data over all the frequencies of electromagnetic spectrum. |
| 2. | It can penetrate solids. | It cannot penetrate solids. |
| 3. | Data transfer rate is slow. | Data transfer rate is very fast. |
| 4. | More number of Wi-Fi signals create noise in a particular area. | Such a type of problem is not faced by Li-Fi. |

### *Advantages*

1. Li-Fi can be used in traffic signals, which will communicate with the LED lights of the cars, thus reducing the accident numbers. In order to transfer the data, thousand and millions of street lamps can be transferred to Li-Fi lamps.
2. Even the petroleum or chemical plants can use Li-Fi, where other transmission or frequencies could be hazardous.
3. Certain electromagnetic sensitive areas like aircraft cabins, hospitals and nuclear power plants can use Li-Fi with advantage of no electromagnetic interference.
4. In terms of capacity, Li-Fi has almost no limitations. The visible light spectrum is 10,000 times larger than the entire radio frequency spectrum.
5. Researchers have reached data rates of over 224 gigabits per second, which is much faster than a typical fast broadband.
6. In terms of cost-effectiveness, Li-Fi is expected to be ten times cheaper than Wi-Fi.

### *Disadvantages*

1. Effective for short range
2. Low reliability
3. The installation cost is high

**SHORT RANGE DEVICES (SRD)**

Short Range Devices (SRD) are radio devices those have low risk of interference with other radio services because of their transmitted power, and hence their range, is low. 'Short Range Device' may be applied to many different types of wireless equipment, including various forms of:

- Access control (including door and gate openers)
- Alarms and movement detectors
- Closed-circuit television (CCTV)
- Cordless audio devices, including wireless micro-phones
- Industrial control
- Local Area Networks
- Medical implants
- Metering devices
- Remote control
- Radio frequency identification (RFID)
- Road Transport Telematics
- Telemetry (the process of recording and transmitting the readings of an instrument)

Short range devices often benefit from a relaxed regulatory regime compared with other radio communication equipments. As a general principle, a user is licence free to operate such equipment, some specific cases may require an individual licence.

However, like all radio equipment, SRDs have to meet the Radio Equipment Directive (RED) to be placed on the market within the European Community. The operation of the equipment is subject to the frequency management regulations of the relevant member state.

## 11.23 WHITE-Fi

- 'White-Fi' technology uses the unused spectrum in frequencies used for broadcasting of television signals. Microsoft's pilot project is expected to offer solution for tackling the problem of last mile broadband connectivity in the country.
- The 200–600 megahertz frequency is used for TV channels to carry data. Sufficient space has to be left so that even when tropospheric propagation conditions increase the distances over which signals can be received, interference does not normally occur.
- This means that there are significant areas where these channels are unused and this leads to very poor spectrum use efficiency. 93 per cent of this spectrum is not utilised in India.
- So, the advantageous 'White-Fi' will provide connectivity using this vacant spectrum.
- In terms of technology parlance, White Space is the name given to these unused spectrum spaces. With a main objective to provide free last mile Internet access to users, many technology companies are considering using this technology.

- The government plans to use the national optic fibre network project to deliver e-services to each of the country. This is one of the prominent features under the 'Digital India' initiative. While this network will be deployed at the gram panchayat level, reaching the end consumer may still require wireless technology (particularly in far-flung areas).
- The technology is implemented in Kenya, Singapore, the US and London with the help of Microsoft.

## 11.24 VIRTUAL PRIVATE NETWORK (VPN)

- VPN stands to be a popular way to **support remote workers**, especially in fields where privacy is paramount, like healthcare.

An additional feature to the process is Remote Desktop Virtualisation. The entire desktop and applications run on a remote server, and are accessed from a client, which can run on a conventional laptop, mobile devices like tablets or even the smartphones. Such a feature makes virtual desktops great for supporting BYOD (bring your own device) schemes. Since the date lives on a central server, even if the device gets lost or stolen, you can be relieved about the safety of the data. The biggest known vendors of virtual desktops are Citrix and VMware.

When VPN gets connected to a computer (or different device, such as a tablet or a smartphone), the computer behaves to be on the similar local network as that of VPN. The whole traffic of network is sent to the VPN over a secured connection. The behaviour of computer on the similar network, further assists us in securing access to resources of local network even though we are on the other side of the world. Being present at the location of VPN, we can access Internet along with certain benefits if we are making use of pubic Wi-Fi or accessing the geo-blocked websites.

### *Uses for VPNs*

In spite of being a simple tool, it is used for doing a wide range of things:

- **Accessing a Business Network during Travelling.**
- **Accessing Home Network During Travelling.**
- **Hiding Your Browsing Activity from Local Network and ISP.**
- **Accessing of Geo-Blocked Websites:** Being an American, if you try to access your Netflix account during travelling from USA or want to use American media sites such as Pandora, and Hulu, a VPN connection located in the USA enables you to access these region-restricted services.
- **Files Downloading:** Many people use VPN connections for file downloads *via* Bit Torrent. It is useful when you are downloading totally legal torrents, even if your ISP is choking Bit Torrent and further extremely slowing it.

## 11.25 VoIP (VOICE OVER INTERNET PROTOCOL/INTERNET TELEPHONY)

VoIP is an IP-enabled voice calling technology over the Internet, e.g., Skype, Yahoo messenger, MSN messenger. It requires broadband connectivity to make a call along with IP-enabled devices like Computers, Smartphone, etc. The voice is converted into digital packets and transmitted to destination over packet switched network.

### *Advantages of VoIP are:*

- Cost of calling is cheaper than normal phone.
- No need to carry a dedicated device for calling if you just have a computer with you.
- Its uses existing LANs so there is no need of dedicated wiring features and hence reduces the complexity of calling.
- Call anywhere anytime; do not worry about roaming features and cost.
- One payment, two services: voice calling and broadband data usage.

### *Disadvantages of VoIP are*

- It is dependent on broadband network connectivity: no Internet, no calling.
- The quality of voice depends on broadband bandwidth and speed.
- Power shortage can hamper VoIP calling as it is totally dependent on power-enabled devices.
- No emergency calling features like normal and Smartphone.

- Highest disadvantage of VoIP is security. It is really tough to trace the source and identity if any imposter is at work.
- Threats like phishing, spoofing and sniffing, call tampering, etc., are very common.

## 11.26 HIDDEN PART OF INTERNET: DARK NET, DARK WEB AND DEEP WEB

Internet is **very vast** and what we use on daily basis is only a small part of it.

The **internet** is the global system of **interconnected computer networks** that uses the internet protocol suite (TCP/IP) to **communicate between networks and devices.**

The Internet carries a vast range of information resources and services, such as the **inter-linked hypertext documents and applications of the World Wide Web (WWW), electronic mail, telephony, and file sharing.**

### Web

- The **Web (WWW)**, is an **information system where documents and other web resources are identified** by Uniform Resource Locators (URLs, such as https://example.com/), which may be interlinked by hyperlinks, and are accessible over the Internet.
- The **resources of the Web are transferred via the Hypertext Transfer Protocol (HTTP), may be accessed using *web browser***, and are published on ***web server.***
- The World Wide Web is built on top of the Internet, which pre-dated the Web by over two decades.

(Refer Infographic – Dark Web vs Deep Web vs Surface Web)

### Surface Web

- Also called the **Visible Web, Indexed Web, Indexable Web** or **Lightnet.**
- It is the portion of web which is **readily available to the general public and searchable** with standard web search engines
- The **Surface Web is made with a collection of public Web pages on a server** accessible by any search engine.

### Deep Web

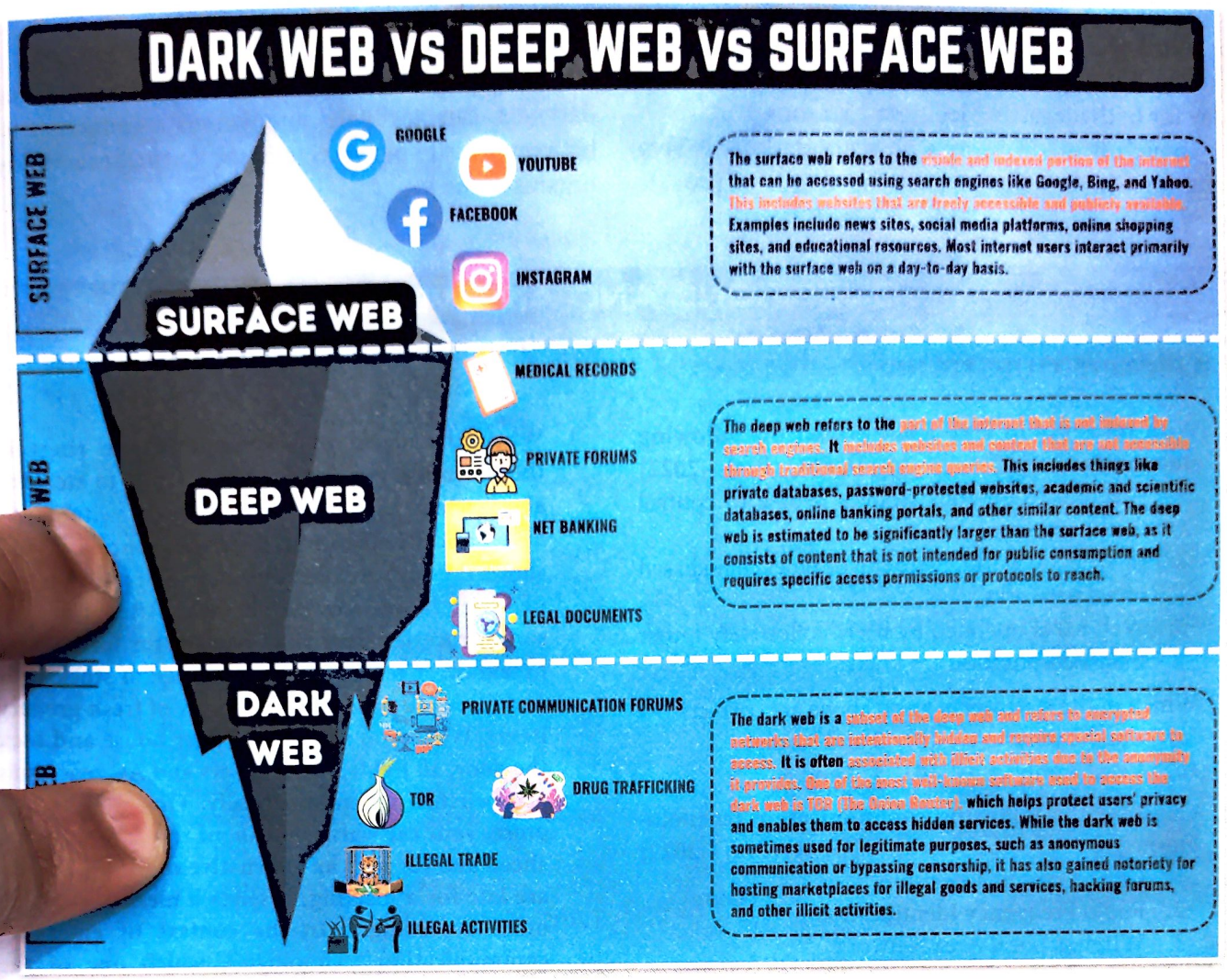
- It is also called **invisible web** or **hidden web**
- It is the **part of the web which cannot be accessed by the normal search engines**, such as Google, Bing and Yahoo. Example – government private data, bank data, cloud data etc.
- Contents of Deep Web are **not indexed by standard web search-engines.**
- **These data are sensitive and private** and thus is kept **out of reach of normal public.**
- It is used to **provide access to a specific group of people.**
- The contents of the deep web range from pages that were not indexed by search engines, Example – paywalled sites, private databases and the dark web.

#### *What is meant by no indexing?*

- No index means that a **web page shouldn't be indexed by search engines** and therefore shouldn't be shown on the search engine's result pages.
- The **robots meta tag is a piece of code** in the head section of a web page.
- **It tells search engines how to crawl** and whether to index a page.

### Dark Web

- The **dark web** is the World Wide Web content that exists on darknets.
- The dark web is a small part of the deep web which is the part of the Web not indexed by web search engines.
- Private computer networks can communicate and conduct business anonymously through dark web, without revealing information, such as a user's location.
- Dark Web is the most hidden part of the Internet, not much people know about it.
- The Dark Web is also called the black world of the internet because many illegal acts like hacking, online robbery, human trafficking, arms sales and drugs supply etc. takes place on the Dark Web .
- One example is a website called the silk road which was on darknet called TOR, used to sell drugs and was taken down by FBI.
- Anyone can use the Dark Web, but the number of people doing illegal work are more on Dark Web. The main reason behind this is that no one


DARK WEB VS DEEP WEB VS SURFACE WEB
SURFACE WEB
GOOGLE
YOUTUBE
FACEBOOK
INSTAGRAM
SURFACE WEB
The surface web refers to the visible and indexed portion of the internet that can be accessed using search engines like Google, Bing, and Yahoo. This includes websites that are freely accessible and publicly available. Examples include news sites, social media platforms, online shopping sites, and educational resources. Most internet users interact primarily with the surface web on a day-to-day basis.
MEDICAL RECORDS
PRIVATE FORUMS
DEEP WEB
NET BANKING
LEGAL DOCUMENTS
The deep web refers to the part of the internet that is not indexed by search engines. It includes websites and content that are not accessible through traditional search engine queries. This includes things like private databases, password-protected websites, academic and scientific databases, online banking portals, and other similar content. The deep web is estimated to be significantly larger than the surface web, as it consists of content that is not intended for public consumption and requires specific access permissions or protocols to reach.
DARK WEB
PRIVATE COMMUNICATION FORUMS
TOR
DRUG TRAFFICKING
ILLEGAL TRADE
ILLEGAL ACTIVITIES
The dark web is a subset of the deep web and refers to encrypted networks that are intentionally hidden and require special software to access. It is often associated with illicit activities due to the anonymity it provides. One of the most well-known software used to access the dark web is TOR (The Onion Router), which helps protect users' privacy and enables them to access hidden services. While the dark web is sometimes used for legitimate purposes, such as anonymous communication or bypassing censorship, it has also gained notoriety for hosting marketplaces for illegal goods and services, hacking forums, and other illicit activities.

can trace who uses the Dark Website as it lies on darknet.

### Darknet

It is a **network build over the internet which is encrypted** that is it can **only be accessed with specific software, configurations, or authorisation and often uses a unique customised communication protocol.**

**Two typical darknet types** are:

1. **Social networks (usually used for file hosting with a peer-to-peer connection):** Friend-to-Friend is another kind of darknet where two-person transfer data between them anonymously.

   Only concerned people have access to it and it is encrypted and password protected.
2. **Anonymity proxy networks [*via* an anonymised series of connections]**
   - One such darknet is **TOR** (The Onion Router).
   - A special software is required to enter this network like "TOR browser, is required to enter into the TOR's network".
   - TOR can access regular website also, a website on this network has .onion address.

**Freenet is also a darknet** which is used for file transfer anonymously; there are many other darknets available.

Darknet **provides a user with anonymity** and thus, **many hidden services are provided on darknet.**

When a service [Now, popular as dark web] was introduced which allowed someone to host a website on the darknet and remained anonymous, **this attracted people who undertook illegal activities to sells things without getting caught on darknets using darkweb.**

Technology such as TOR, I2P, and Freenet which was intended to defend digital rights by providing security, anonymity, or censorship resistance are used today for both illegal and legitimate reasons.

Though it might seem a bit scary darknet is very useful for which it was created and that is to provide anonymity to people like government official, journalist etc.

Through use of applications such as SecureDrop, darknets can facilitate anonymous communication between whistle-blowers, activists, journalists and news organisations.

## 12.1 SPECTRUM POLICY IN INDIA

### 12.1.1 Spectrum

Spectrum represents a collection of different types of electromagnetic radiations of different wavelengths. All communication signals work on these spectrums. Different types of services like space communication, mobile communication, broadcasting, radio navigation, mobile satellite service, aeronautical satellite services, defence communication, etc., all use and rely on radio frequencies in India. Radio frequency is a natural resource but unlike other natural resource, its major limitation is that it will deplete on use. Additionally, it will be wasted if not used efficiently.

Indian telecom operator uses the spectrum, which is the most crowded and inadequate thing to accommodate the usage by 650 million mobile subscribers as on date. Hence, the quality of customer service deteriorates and leads to poor voice quality, call drop and undelivered messages of mobile services in India.

### Mobile Spectrum

Mobile or cellular spectrum is that part of the whole electromagnetic spectrum, which is used by Indian government to offer mobile services; hence, the name 'Mobile Spectrum'. Generally, following frequencies are used for this purpose – 800 MHz (for CDMA), 900 MHz (for 2G) and 1800 MHz (for 3G/4G). But technically, any frequency band can be used for any purpose; like 900 MHz frequency can be used to deliver 3G services also.

### 12.1.3 Agencies Allocating Spectrum

For international purposes, the international body called International Telecommunication Union (ITU) allocates spectrum. For domestic purposes, it is done by Wireless Planning and Coordination (WPC) wing of the Ministry of Communications, created in 1952. It is the National Radio Regulatory Authority responsible for Frequency Spectrum Management, which includes licensing for the needs of all wireless users in the country. The licences to operate wireless stations are allotted by it.

#### *Reserve Price*

It is the minimum amount set by the government from where auction begins, i.e., it is the starting amount or base price from where the auction starts.

#### *Auction of Spectrum*

- Spectrum is a scarce resource. It needs to be managed efficiently.
- Spectrum cannot be used by many people. It has to be allocated to some persons who can manage the services under it. Hence, it is auctioned.
- Government auctions it because spectrum is a resource of the Government of India. It is not a private property, so government auctions it.
- A lot of revenue is generated by selling the spectrum and that money can be used for developmental programmes in India.

### 12.1.4 Reasons for Superiority of 900 MHz and 1800 MHz Band

According to Physics, for any wave, as the frequency of the wave increases, the distance travelled by it decreases. So naturally, frequencies of 900 MHz will cover more distance than frequencies of 1800 MHz and hence, mobile operators are more interested in the 900 MHz frequency.

More investment is needed by the companies that buy 1800 MHz frequency spectrum, which has poor coverage than the 900 MHz frequency. For matching the existing coverage, mobile operators have to install additional base stations (i.e., mobile towers) to give the same effect (as the frequencies under 900 MHz). Even hardware equipment, required for carrying out operation of 1800 MHz frequency are costly. Main reason behind it is that 900 MHz frequency band has been in use for mobile communications globally for over 20 years and as a result, technology standards have been better developed compared to 1800 MHz band, which has been in use only recently.

### 12.1.5 The Challenges of India's Spectrum Policy

To get advantage of new possibilities for social and economic development, India requires more spectrums. The mobile technology demand is likely to rise quickly in the coming years. Hence, the country needs the spectrum deployment for utilising its commercial in

order to accommodate the mobile broadband growth. The country faces various challenges and difficulties in respect of its spectrum policy, which is summarised as follows:

1. **Lack of Available Spectrum:** There are insufficient bands for the growing mobile demands in India, leading to the issue of availability.
2. **High Costs:** India has one of the highest spectrum costs in the world. India also suffers from high telecommunications costs.
3. **Fragmented and Inflexible Usage:** The spectrum quality is a topic of discussion, as some bands are booked for particular applications, resulting in issues related to the quality of spectrum. For instance, Defence Ministry occupies too much spectrum, at times even more than required and hence, is not fully utilised, thereby limiting the access of the said resources to private.
4. **Auction Outcomes:** Besides the above major issues, another severe problem is cost and availability problems contributed by past spectrum auctions. The dual objectives of the spectrum are: resourceful spectrum allotment to the full utilisation and maximising the revenue of government and hence, the appropriate design of the auctions becomes critical. Due to auction, there are huge level of company debts, unreasonable prices and subsequently, high charges for consumers.

### 12.1.6 Spectrum Auctions

A spectrum auction is a process whereby a government uses an open auction system to sell the rights to transmit signals over specific bands of the electromagnetic spectrum and to assign scarce spectrum resources.

- Devices such as cellphones and wireline telephones require signals to connect from one end to another. These signals are carried on airwaves, which must be sent at designated frequencies to avoid any kind of interference.
- The Union government owns all the publicly available assets within the geographical boundaries of the country, which also include airwaves.
- To sell these assets to companies willing to set up the required infrastructure to transport these waves from one end to another, the central government through the DoT auctions these airwaves from time to time.
- **These airwaves are called spectrum**, which is subdivided into bands which have varying frequencies. All these airwaves are sold for a certain period of time, after which their validity lapses, which is generally set at 20 years.

#### 12.1.6.1 Main Objective of Auction

- To obtain a market-determined price for the spectrum on offer.
- Ensure efficient use of spectrum and avoid hoarding.
- Stimulate competition in the sector and maximise revenue procedure.

#### 12.1.6.2 Spectrum Auctions in India

Devices such as cell phones and wireline telephones require signals to connect from one end to another. These **signals are carried on airwaves,** which must be sent at designated frequencies to avoid any kind of interference.

- The Union government owns **all the publicly available assets within the geographical boundaries of the country, which also include airwaves.**
- With the expansion in the number of cellphone, wireline telephone and Internet users, the need **to provide more space for the signals arises from time to time.**
- **To sell these assets to companies** willing to set up the required infrastructure to transport these waves from one end to another, **the central government through the DoT auctions** these airwaves from time to time.
- **These airwaves are called spectrum,** which is subdivided into bands which have varying frequencies.
- All these airwaves are sold for a certain period of time, after which their validity lapses, which is generally set at 20 years.

## 12.2 BROADBAND POLICY OF INDIA

Broadband is a high-capacity transmission technique, which uses a wide range of frequencies, enabling communication of a large number of messages

simultaneously through coaxial cable, optical fibre, radio or twisted pair.

As the demand for high speed and quality Internet and telecommunication service increases and having the potential of widespread broadband services, **India has taken a Broadband Policy in 2004 aimed at enhancing the quality of life through societal applications which includes tele-medicine, tele-education, e-governance, entertainment, as well as employment generation through high-speed access to information and web-based communication.** Now, high-speed Internet access is available at various speeds from 64 to 128 kilobits per second.

In a competitive environment like today, appropriate steps ensuring required bandwidth available in a time-bound manner within their licence framework is required by service providers. A major cost component for Broadband services is contributed by the bandwidth costs. The DIT, Government of India has established National Internet Exchange of India (NIXI) to ensure that Internet traffic, originating and destined for India, should be routed within India.

## SECTION 66A OF THE INFORMATION TECHNOLOGY ACT

### *Section 66A*

- Section 66A defines the punishment for sending "offensive" messages through a computer or any other communication device like a mobile phone or a tablet.
- If convicted, it can lead to a maximum of 3 years in jail and fine.
- It empowers the police to make arrests over what policemen, in terms of their subjective discretion, could construe as "offensive" or "menacing" or for the purposes of causing annoyance, inconvenience, etc. to the victim.

### *Shreya Singhal* Case

The Supreme Court had in its judgment in the *Shreya Singhal* case struck down Section 66A.

### *SC strike down Section 66A*

The Supreme Court had noted that **Section 66A** arbitrarily, excessively and disproportionately invades the right of free speech, under **Article 19(1)(a) of the Constitution**, and upsets the balance between such right and the reasonable restrictions that may be imposed on such right and the definition of offences under the provision was open-ended and undefined.

The Delhi High Court has asked the Centre to consider a petition seeking to remove provisions from the statute such as Section 66A of the Information Technology Act, which have already been declared unconstitutional.

### *Issues*

There are several criminal law sections that were struck down by the Supreme Court but continue to be used by police officers. In some cases, trial courts went ahead with framing charges under the defunct IT Act provisions, even after taking cognizance of the Supreme Court's 2015 judgment.

## 12.4 DRAFT OF DATA PROTECTION BILL

Personal Data Protection Bill, 2019 play a big role in providing robust protection to users and their personal data. It is now under scrutiny by a Joint Parliamentary Committee.

### *Benefits of Personal Data Protection Bill, 2019*

- **Defining the Roles:** The Bill envisages codifying the relationship between individuals and firms/ state institutions as one between 'data principals' (whose information is collected) and 'data fiduciaries' (those processing the data) so that privacy is safeguarded by design.

  Also, the Bill seeks to apply the data protection regime to both government and private entities across all sectors.
- **Ensuring Data Privacy:** The Bill seeks to emphasise that data principals will have to maintain security safeguards to protect personal data and also have to fulfil a set of data protection obligations and transparency and accountability measures.

  In nutshell, it provides that scrutiny on these entities govern and process personal data to uphold users' privacy and interests.
- **Rights of the Citizens:** The Bill seeks to give users a set of rights over their personal data and means to exercise those rights.

  For instance, a user will be able to obtain information about the different kinds of personal data that an entity has about them and how the entity is processing that data.

- **Establishing a Regulator:** The Bill seeks to create an independent and powerful regulator known as the Data Protection Authority (DPA).

The DPA will monitor and regulate data processing activities to ensure their compliance with the regime. More importantly, the DPA will give users a channel to seek redress when entities do not comply with their obligations under the regime.

Nearly two years after it was constituted on 11 December 2019, the Joint Committee on the Personal Data Protection Bill, 2019, headed by BJP MP P.P. Chaudhary, presented its final report on the upcoming bill in both Houses of Parliament on 16 December. On December 16, 2021, the Joint Committee on Personal Data Protection Bill had tabled its report in both the Houses of Parliament, giving its views on various provisions.

### *Key Recommendations*

- Remove the word 'personal' from the existing title of 'Personal Data Protection Bill'. This is intended to reflect that the bill, in order to ensure privacy, will also be dealing with non-personal data, such as personal data that has been anonymised.
- Amend the section restricting the transfer of personal data outside India to say "sensitive personal data shall not be shared with any foreign government or agency unless such sharing is approved by the central government.
- No social media platform be allowed to operate in India unless its parent company, which controls the technology powering its services, sets up an office in the country.
- It proposes a separate regulatory body to be set up to regulate the media.
- Jail term of up to 3 years, fine of ₹2 lakh or both if de-identified data is re-identified by any person.
- Central government may exempt any government agency from the legislation only under exceptional circumstances.

### *How do these recommendations compare with EU regulation?*

- The Joint Committee of the Parliament (JCP) recommendations on the Personal Data Protection Bill are in some aspects very similar to global standards such as European Union's General Data Protection Regulation.

### *Similarities*

- **Consent:** Users must have informed consent about the way their data is processed so that they can opt in or out of it.
- **Breach:** Authorities must be notified of a breach within 72 hours of the leak.
- **Transition period:** Two-year transition period for provisions of General Data Protection Regulation (GDPR) to be put in place.
- **Data fiduciary:** Under EU law, a data fiduciary is any natural or legal person, public authority, agency or body that determines purpose and means of data processing. In India, it also includes NGOs.

### *Formation of a Data Protection Authority (DPA)*

The Data Protection Authority (DPA) will be dealing with privacy and personal data as well as non-personal data.

### *Composition of DPA*

- The Chairperson and the members of the DPA shall be appointed by the Union government based on the recommendation of a selection committee chaired by the Cabinet Secretary.
- Other members of the committee would be the Attorney General of India, the IT and law secretaries.
- **Nominated members:** An independent expert and a director each from the IIT and the IIM will be nominated by the Centre.

### *Other Highlights of the Bill*

The Bill proposes to specify the flow and usage of personal data, protect the rights of individuals whose personal data are processed, as it works out the framework for the cross-border transfer, accountability of entities processing data, and moots remedies for unauthorised and harmful processing.

It also seeks to provide the government with powers to give exemptions to its probe agencies from the provisions of the legislation, a move that has been strongly opposed by the opposition MPs who had filed their dissent notes. The Bill is now expected to be introduced in the Parliament in the upcoming monsoon session, which begins on July 20 and ends on August 11, 2023.

## 12.5 DATA LOCALISATION

Data localisation is the **act of storing data on any device that is physically present within the borders of a specific country where the data was generated.**

### *Why is Data Localisation Necessary for India?*

- For securing citizen's data, data privacy, data sovereignty, national security and economic development of the country.
- Recommendations by the RBI, the **committee of experts led by Justice BN Srikrishna,** the draft e-commerce policy and the draft report of the cloud policy panel show signs of data localisation.
- The extensive data collection by technology companies has allowed them to process and monetise Indian users' data outside the country. Therefore, **to curtail the perils of unregulated and arbitrary use of personal data, data localisation is necessary.**
- Digital technologies like Machine Learning (ML), Artificial Intelligence (AI) and Internet of Things (IoT) can generate tremendous value out of various data. It can **turn disastrous if not contained within certain boundaries.**
- With the advent of cloud computing, Indian users' data is outside the country's boundaries, leading to a conflict of jurisdiction in case of any dispute.
- Data localisation is an **opportunity for Indian technology companies to evolve an outlook from services to products.** ***International companies will also be looking at the Indian market, and this will benefit the growth of the local ecosystem.***
- More data centres in India mean new, **power-hungry customers for India's renewable energy market.** That means data localisation could boost India's renewable energy.

### *Policies that Imply Data Localisation*

- The **Srikrishna Committee** wants to localise data for law enforcement to have easy access to data, to ***prevent foreign surveillance*** and to ***build an artificial intelligence ecosystem*** in India and also because undersea cables through which data transfers take place are vulnerable to attacks.
- **Reserve Bank of India has also imposed *a hard data localisation mandate on payment systems providers to store payment systems data only in India.***
- Barring limited exceptions, telecom service providers are not allowed to transfer user information and accounting information outside India.
- Goals set in the **Draft National Digital Communications Policy 2018 and the Guidelines for Government Departments for Contractual Terms related to Cloud Storage 2017,** draft e-commerce policy and the draft report of the cloud policy panel show signs of data localisation.

### *Concerns/Challenges*

- Several recommendations including the draft e-commerce policy, falter on a key ground like they gloss over the negative economic impact of data localisation. This approach exhibits lack of evidence-based policy making.
- Having data in India does not mean that domestic companies will be able to access this data. Localisation might aid the growth of the data centres and the cloud computing industry in India, but as a matter of wider public policy, such an approach is extremely myopic.
- Mandating localisation is less of a solution for data protection and might be less relevant to promote e-commerce.
- Given the comparative trade advantages enjoyed by one section of Indian industry in this context, mandating a strict data localisation regime could be perceived as a restrictive trade barrier and spur retaliatory measures.
- There is a possible rise in prices of foreign cloud computing services in case of a data localisation and its impact on MSMEs as well as start-ups relying on these services.
- The possibility of triggering a vicious cycle of data localisation requirements by other countries as a response to India's possible data localisation will be detrimental for the global data economy.
- Growth will be restricted if data cannot be aggregated internationally. Infrastructure in India for efficient data collection and management is lacking.

*Need of the Hour*

- There is an urgent need to have an integrated, long-term strategy for policy creation for data localisation.
- Data localisation needs **to integrate a wide range of social, political and economic perspectives.**
- Creating an opportunity ***for local data centres all over the country.***
- Devising an optimal ***regulatory and legislative framework for data processors and data centres operating in the country.***
- ***Adequate infrastructure*** in terms of energy, real estate and Internet connectivity also needs to be made available for India to become a global hub for data centres.
- ***Adequate attention needs*** to be given to the interests of India's **Information Technology Enabled Services (ITeS) and Business Process Outsourcing (BPO) industries,** ***which are thriving on cross border data flow.***

## 12.6 NATIONAL SUPERCOMPUTING MISSION (NSM)

The 2020–21 was an important year for India's National Supercomputing Mission (NSM).

The mission was set up to provide the country with supercomputing infrastructure to meet the increasing computational demands of academia, researchers and start-ups by creating the capability design, manufacturing of supercomputers indigenously in India.

A first of its kind attempt to boost the country's computing power, the National Super Computing Mission is **steered jointly by the Ministry of Electronics and IT (MeitY) and Department of Science and Technology (DST) and implemented by the Centre for Development of Advanced Computing (C-DAC), Pune and the Indian Institute of Science (IISc), Bengaluru.**

The target of the mission was set to establish a network of supercomputers, ranging from a few Tera Flops (TF) to Hundreds of Tera Flops (TF) and three systems with greater than or equal to 3 Peta Flops (PF) in academic and research institutions of national importance across the country by 2022.

This network of supercomputers envisaging a total of 15–20 PF was approved in 2015 and was later revised to a total of 45 PF (45000 TFs), a jump of 6 times more computing power within the same cost and capable of solving large and complex computational problems.

With the revised plan in place, the first supercomputer assembled indigenously, called **Param Shivay,** was installed in IIT (BHU). Similar systems **Param Shakti** and **Param Brahma** were installed at **IIT-Kharagpur and IISER, Pune.** ***They are equipped with applications from domains like Weather and Climate, Computational Fluid Dynamics, Bioinformatics and Material science.***

Geared to provide supercomputing facility to about 60–70 institutions nation-wide and more than thousands of active researchers, academicians, and so on, NSM has gathered momentum and is moving fast not only towards creating a computer infrastructure for the country but also to build capacity of the country to develop the next generation of supercomputer experts.

*Significance*

- Global supercomputing services have facilitated countries in their science and technology abilities in areas such as designing of vehicles, aeroplanes, massive structures, such as high rise buildings and bridges, infrastructure, new life saving drugs discovery, discovery and extraction of new energy sources including oil, natural gas, etc.
- Throughout the years, supercomputers have helped mankind in several ways. Weather prediction has achieved forecasting as well as real time tracking accuracy of natural phenomenon. Timely warnings of cyclones, in the recent past, have saved many lives and property. The Mission plans to promote such capabilities beyond the present levels.

## 12.7 CLOUD COMPUTING

### 12.7.1 Basics of Cloud Computing

Cloud Computing uses the Internet and central remote servers to maintain data and applications. The consumers can access their personal files at any computer with Internet access. This technology is more efficient because it enables computing through centralised storage, memory, processing and bandwidth.

Yahoo mail or Gmail are simple examples of cloud computing. It does not require software or a server

to use them. The consumers just require an Internet connection to send emails. All the management of server and email is done on the cloud (Internet) and it is overall managed by the cloud service provider like Yahoo, Google, etc. It is more advantageous since the consumer gets to use the software alone and avail the benefits.

**Two main types of clouds** are **private** and **public**. Services sold by public cloud are available for anyone on the Internet. Now, the largest public cloud provider is Amazon Web Services. On the other hand, a private cloud represents a proprietary network or a data centre, supplying hosted services to limited number of people. A virtual private cloud can be created by using public cloud resources to establish a private cloud. Be it private or public, cloud computing aims at easy, scalable access to IT services and computing resources.

### *Categories of Cloud Computing*

Anything that includes delivering hosted services over the Internet comes under the broad umbrella of Cloud Computing. The services so provided are broadly of three categories, as follows:

1. Infrastructure-as-a-Service (IaaS)
2. Platform-as-a-Service (PaaS)
3. Software-as-a-Service (SaaS)

The Internet in flowcharts and diagrams is often represented by the symbol of cloud and this inspired the technology to be named as Cloud Computing.

### *Various types of Clouds*

1. Public Cloud
2. Private Cloud
3. Community Cloud
4. Hybrid Cloud

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Note: **iCloud**

The cloud storage and cloud computing service from Apple Inc. is named as iCloud. The users can store data, such as music files on remote computer servers for downloading in multiple devices, such as iOS-based devices and personal computers running OS X or Microsoft Windows, using this service. It also serves as a placement for Apple's Mobile Me service, which acts as a data-syncing centre for email, contacts, calendars, bookmarks, notes, to-do lists and other data. Up to 5 GB, the users enjoy free storage facility, above which it is a paid service.

Note: Apple Inc. announced iCloud on 06 June 2011 at the Apple World-Wide Developers Conference (WWDC).

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(Refer **Infographic – Cloud Computing & Cloud Hosting**)

## 12.8 GRID COMPUTING

Grid systems serve for collaborative sharing of resources. It may also be used as distributed and large-scale cluster computing. A grid basically uses the processing capabilities of different computing units for processing a single task. The way it works is as follows: The task is divided into multiple sub-tasks; and each machine on a grid is assigned a task. On completion of the sub-tasks, they are sent back to the primary machine (taking care of all the tasks). As a final step, they are combined or clubbed together as an output.

### *Cloud versus Grid Computing*

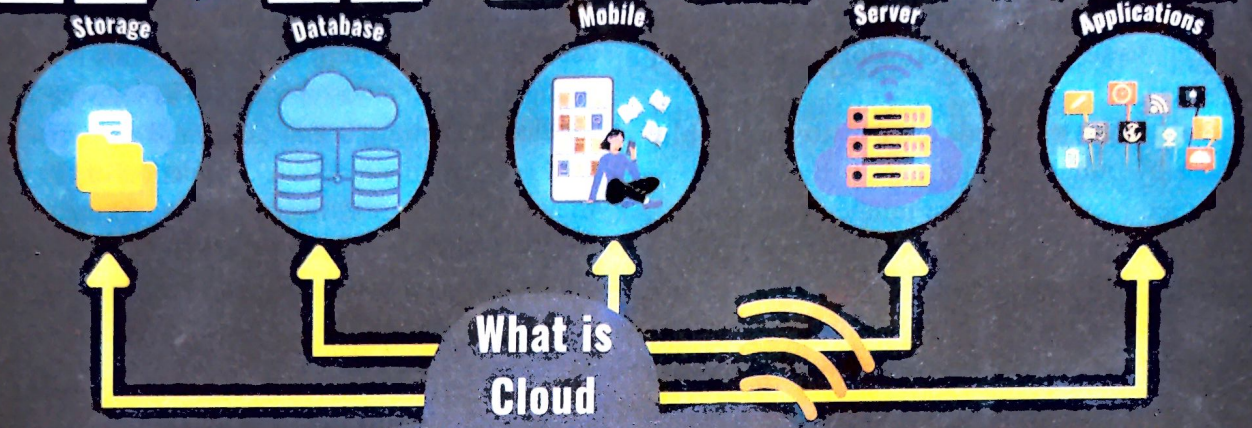
1. The services offered by cloud are more than that of grid computing. As a matter of fact, cloud provides almost all the services on the Internet, ranging from web hosting, multiple operating systems, DB support and much more.
2. In grid system, server computers are still needed to distribute the pieces of data and collect the results from participating clients on grid.
3. Grids tend to be more loosely coupled, heterogeneous and geographically dispersed when compared with conventional cluster computing systems.

## 12.9 NATIONAL INTELLIGENCE GRID (NATGRID)

NATGRID is a unified intelligence grid through which the government's core security agencies' databases are interlinked. This enables collection of comprehensive patterns of intelligence that the intelligence agencies can readily access. Soon after the attack of 26/11 in 2008, the requirement of such agency was realised, and hence, it was first proposed by the government of India, in July 2016. Ashok Patnaik was appointed as the Chief Executive Officer of the National Intelligence Grid.

American Lashkar operative David Coleman Headley had visited the country many times, before the attack of 26/11 and performed a comprehensive study of the places that later became the places of attack. In spite of travelling numerous times to India and further returning to the US through Pakistan or West Asia, Indian agencies did not have any doubt, due to the lack of a system which did not identify a pattern in his strange travel itineraries. It is observed that if a system similar to the NATGRID was there before the attack, Headley would have been easily detained.

# CLOUD COMPUTING




## What is Cloud Computing?

Cloud computing is the delivery of computing resources, such as servers, storage, databases, software, and applications, over the internet. It allows users to access and utilize these resources on-demand, without the need for physical infrastructure, while offering scalability, cost efficiency, and flexibility.

Cloud computing uses remote servers over the internet to store, manage, and process data and applications, providing flexible and scalable access to computing resources.

Cloud computing data is stored in large data centers operated by cloud service providers. These data centers can be located in various geographic locations around the world.

## What are Different Types of Clouds?

### Private Cloud

Dedicated to a single organization

Private cloud is an exclusive computing environment for a single organization, typically within their own data center or infrastructure. It offers enhanced control, security, and privacy compared to public cloud solutions. The organization has direct oversight and can customize the cloud environment to meet their specific needs.

### Public Cloud

Shared computing resources over the internet.

Public cloud is a computing model where shared resources and services are provided to the public via the internet by third-party providers. It offers scalability, cost-efficiency, and convenience, eliminating the need for organizations to manage their own infrastructure.

### Hybrid Cloud

Combination of public and private clouds.

Hybrid cloud combines public and private clouds, allowing organizations to integrate workloads and maintain sensitive data securely while leveraging the scalability of the public cloud for non-sensitive workloads.

### Community Cloud

Shared cloud infrastructure for specific community groups.

Community cloud is a shared cloud computing model for multiple organizations with similar interests or requirements. It allows participants to collaborate, share resources, and meet common goals while maintaining control over their own data and applications.

## What are Different Cloud Service Model?

### IaaS

(Infrastructure as a Service)

IaaS is a cloud computing model where virtualized computing resources are accessed and managed over the internet. It provides on-demand provisioning of infrastructure components like virtual machines, storage, and networks without the need for physical hardware ownership or maintenance. It offers flexibility, scalability, and cost-efficiency, allowing organizations to focus on their applications and data while leaving infrastructure management to the service provider.

### SaaS

(Software as a Service)

SaaS is a cloud computing model that delivers software applications over the internet on a subscription basis. Users can access and use the software directly from a web browser without installation or local infrastructure. The service provider handles software maintenance, updates, and security. SaaS offers easy accessibility, scalability, and cost-effectiveness, allowing organizations to focus on software usage rather than infrastructure management.

### PaaS

(Platform as a Service)

PaaS is a cloud computing model that offers a platform for developing, testing, and deploying applications without managing the underlying infrastructure. It provides pre-configured development tools and runtime environments, enabling developers to focus on application development and functionality. PaaS offers scalability, ease of deployment, and cost-efficiency, eliminating the need for organizations to invest in infrastructure for application development and hosting.

# Advantages of CLOUD COMPUTING

### Less Costs
Cloud computing eliminates the need for large upfront capital expenditures and costly hardware investments. With a subscription-based model, you only pay for the resources you use, making it a cost-effective option for businesses.

### Anytime Availability
The majority of cloud providers offer highly reliable services, maintaining an impressive uptime of 99.9%.

### Flexible Capacity
Cloud computing provides a flexible infrastructure that can be easily scaled up, down, or turned off according to the user's needs and circumstances.

### Functioning
One of the advantages of cloud computing is the ability to work from anywhere in the world, as long as you have an internet connection.

### Carbon Footprints
Cloud computing allows organizations to minimize their environmental impact by optimizing resource utilization and avoiding unnecessary over-provisioning, thereby reducing their carbon footprint.

### Updates on Software
In cloud computing, server providers regularly update your software, including security updates, relieving you from the burden of spending valuable time on system maintenance.

### Collaborations
Cloud applications foster collaboration by empowering diverse groups of individuals to virtually connect, share information, and utilize shared resources for enhanced teamwork.

### Security
Cloud computing provides robust security measures to protect sensitive data. In the event of data loss on your computer, the data stored in the cloud can be easily accessed, ensuring its availability and preventing data loss.

### Documents Control
Prior to the emergence of cloud computing, workers had to rely on email attachments to share files, resulting in a chaotic mix of conflicting titles, formats, and content when multiple users attempted to collaborate on them simultaneously.

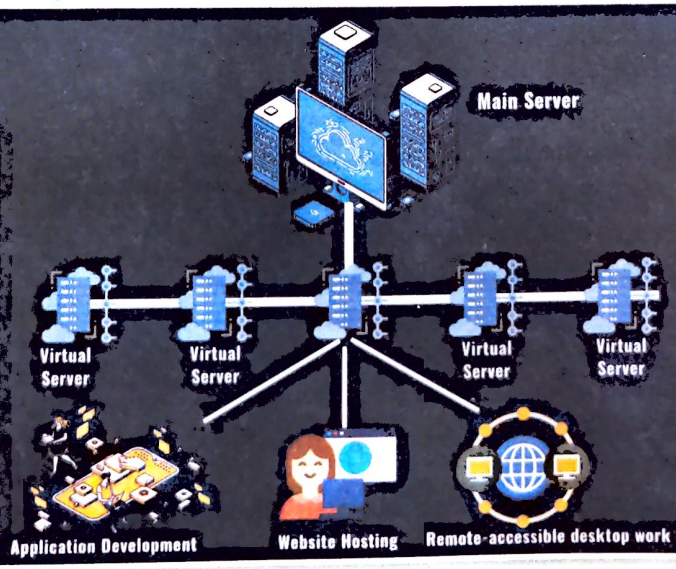
### Maintenance
Cloud computing streamlines and enhances IT maintenance and management by providing SLA-backed agreements, centralized resource administration, and managed infrastructure, resulting in simplified operations and improved efficiency.

CLOUD SERVICES

aws Dropbox NETFLIX

## What is Cloud Hosting?

Cloud hosting is a type of web hosting service that utilizes multiple interconnected servers to host websites and applications. Instead of relying on a single physical server, cloud hosting distributes the resources and workload across a network of servers, often referred to as a "cloud." This distributed infrastructure provides scalability, reliability, and flexibility, allowing websites and applications to handle high traffic volumes and adapt to changing resource demands. Cloud hosting also offers features such as redundancy, load balancing, and automatic resource allocation, making it a popular choice for businesses that require robust and flexible hosting solutions.



**KEYNOTE**

- It is an ambitious **counter terrorism programme.**
- It will **utilise technologies** like Big Data and analytics to study and analyse the huge amounts of data from various intelligence and enforcement agencies to **help in tracking suspected terrorists and prevent terrorist attacks.**
- It will **connect, in different phases, data providing organisations and users** besides developing a legal structure through which information can be accessed by the law enforcement agencies.
- NATGRID is a post Mumbai 26/11 attack measure.

NATGRID is an intelligence network of information sharing. It collates the data from individual databases of the different agencies and ministries. It acts as an efficient counter-terrorism measure by further combining the data from different government databases. Such databases include bank and tax account details, transactions of credit card, records of visa and immigration and itineraries of rail and air travel. The **11 central agencies** that can take advantage of this network include: Research and Analysis Wing, Intelligence Bureau, Central Bureau of Investigation, Financial Intelligence Unit, Central Board of Direct Taxes, National Investigation Agency (NIA), Enforcement Directorate, Directorate of Revenue Intelligence, Narcotics Control Bureau, Central Board of Excise and Customs and Directorate General of Central Excise Intelligence.

### *Criticisms*

- NATGRID is facing opposition on charges of possible violations of privacy and leakage of confidential personal information.
- Its efficacy in preventing terror has also been questioned, given that no state agency or police force has access to its database, thus reducing chances of immediate and effective action.
- According to few experts, digital databases such as NATGRID can be misused. Over the last two decades, the very digital tools that terrorists use have also become great weapons to fight the ideologies of violence.
- Intelligence agencies have also opposed amid fears that it would impinge on their territory and possibly result in leaks on the leads they were working on to other agencies.

### *Why do we need NATGRID?*

- The danger from not having a sophisticated tool like the NATGRID is that it forces the police to rely on harsh and coercive means to extract information in a crude and degrading fashion.
- After every terrorist incident, it goes about rounding up suspects – many of who are innocent. If, instead, a pattern search and recognition system were in place, these violations of human rights would be much fewer.
- NATGRID would also help the Intelligence Bureau keep a tab on persons with suspicious backgrounds.
- The police would have access to all his data and any movement by this person would also be tracked with the help of this data base.

NATGRID was opposed on grounds of possible violations of privacy and leakage of confidential personal information. Even its efficacy in preventing terror has been questioned, given that no state agency or police force has access to its database; thus reducing immediate actions sensing threat due to terrorism, its efficiency in preventing terror has been questioned.

**KEYNOTE**

**The National Intelligence Grid (NATGRID) has signed a memorandum of understanding with the National Crime Records Bureau (NCRB) to access the centralised online database on FIRs and stolen vehicles.**

**Who can access the data?**

- **It will be a medium for at least 11 Central agencies** such as the Intelligence Bureau (IB) and the Research and Analysis Wing (R&AW) to access data on a secured platform.
- **The data will be procured by NATGRID from 21 providing organisations such as the telecom, tax records, bank, immigration, etc.**

## 12.10 ENCRYPTION

The most effective way of providing data security is Encryption. Encrypted data represents a type of code text. You must have access to a secret key or password, which can enable you to decrypt it, thus helping to read an encrypted file. On the contrary, an unencrypted data represents a plain text.

It is a very effective tool for the security of important data by excluding the unauthorised access. It can be done through providing the decryption code only to the authorised persons.

Military and governments have been using encryption since long, in order to facilitate secret communication. In recent times, it is more commonly used in protecting information within several kinds of civilian systems including WhatsApp, Viber, which use end-to-end encryption (E2EE). Here, except the sender and the receiver no one can decrypt the encrypted data.

There are two types of **encryption: Symmetric encryption,** a simple type of encryption where only private key is used; and **Asymmetric encryption,** which is a relatively complex type of encryption. Here, a public key, which is known to all recipients is used to decrypt the message and also the private key. But, **WhatsApp uses more complex types of asymmetric encryption.** It uses three types of public key and here, the private key varies in each message sent and gets encrypted without any intervention of the user.

### *Encryption Level and Issue of Security*

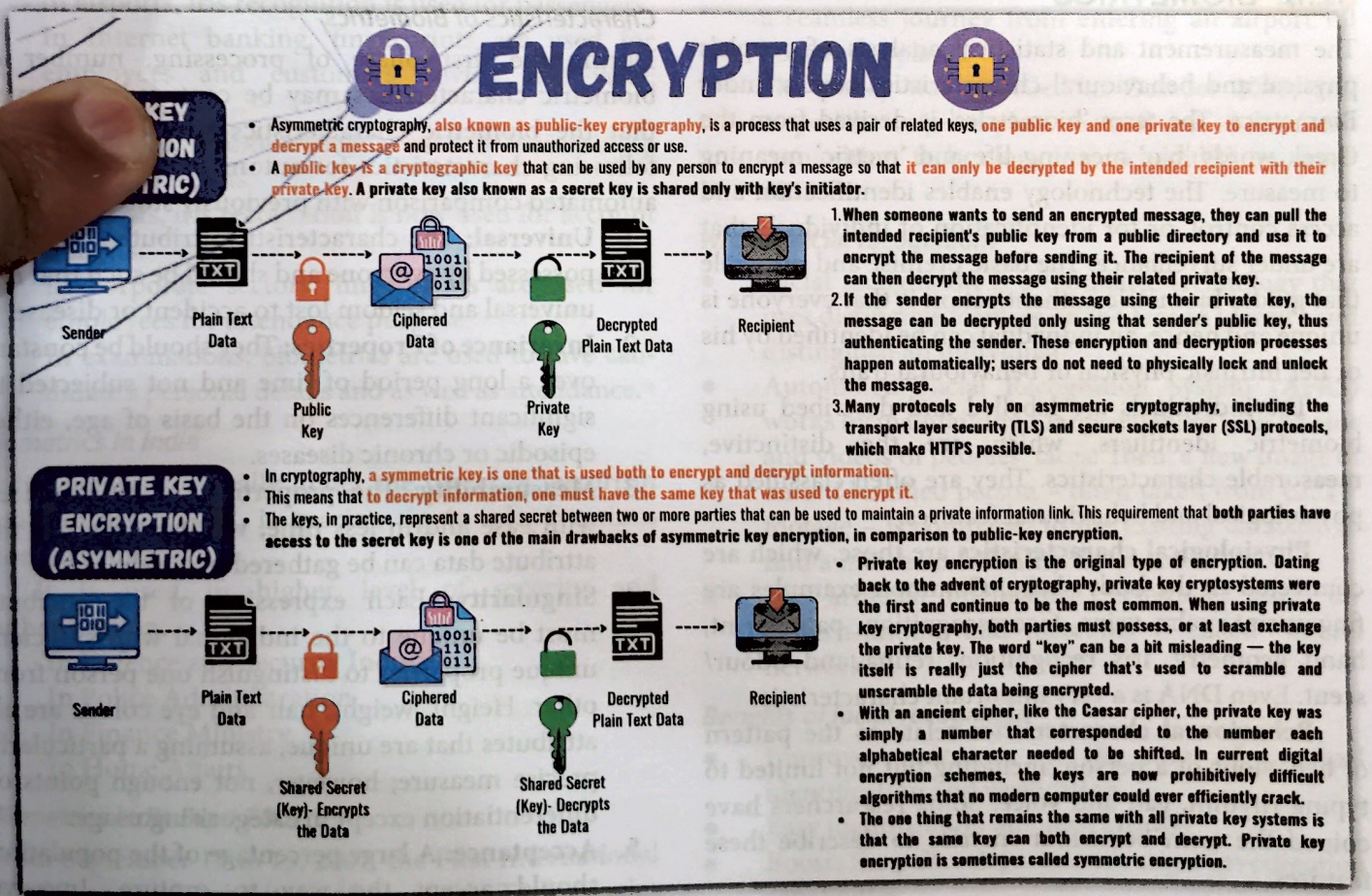
Encryption is a challenge, not only for India but also for the world to enforce law. In India, the telecom sector is limited to the encryption of 40 bits; however, the **2015 draft encryption policy recommended the use of 256-bit key for encryption and promoting the use of Digital Signature, thereby envisioning a secure cyberspace.**

After the Pathankot Attack in 2016, it raised questions on the government's regulation policy regarding encryption. Keeping in mind that a strong regulation can hamper the innovation of encryption technology, the Indian government has to make a policy that can control the terrorist and criminal activities.

(Refer Infographic – Encryption)

## 12.11 WEARABLE TECHNOLOGY

Wearable electronics are the next big innovation in the world of technology after the invention of smartphones. **Wearables are electronic technology or devices incorporated into items that can be comfortably**


ENCRYPTION
• Asymmetric cryptography, also known as public-key cryptography, is a process that uses a pair of related keys, one public key and one private key to encrypt and decrypt a message and protect it from unauthorized access or use.
• A public key is a cryptographic key that can be used by any person to encrypt a message so that it can only be decrypted by the intended recipient with their private key. A private key also known as a secret key is shared only with key's initiator.
Sender
Plain Text Data
Public Key
Ciphered Data
Private Key
Decrypted Plain Text Data
Recipient
1. When someone wants to send an encrypted message, they can pull the intended recipient's public key from a public directory and use it to encrypt the message before sending it. The recipient of the message can then decrypt the message using their related private key.
2. If the sender encrypts the message using their private key, the message can be decrypted only using that sender's public key, thus authenticating the sender. These encryption and decryption processes happen automatically; users do not need to physically lock and unlock the message.
3. Many protocols rely on asymmetric cryptography, including the transport layer security (TLS) and secure sockets layer (SSL) protocols, which make HTTPS possible.
PRIVATE KEY ENCRYPTION (ASYMMETRIC)
• In cryptography, a symmetric key is one that is used both to encrypt and decrypt information.
• This means that to decrypt information, one must have the same key that was used to encrypt it.
• The keys, in practice, represent a shared secret between two or more parties that can be used to maintain a private information link. This requirement that both parties have access to the secret key is one of the main drawbacks of asymmetric key encryption, in comparison to public-key encryption.
Sender
Plain Text Data
Shared Secret (Key)- Encrypts the Data
Ciphered Data
Shared Secret (Key)- Decrypts the Data
Decrypted Plain Text Data
Recipient
• Private key encryption is the original type of encryption. Dating back to the advent of cryptography, private key cryptosystems were the first and continue to be the most common. When using private key cryptography, both parties must possess, or at least exchange the private key. The word "key" can be a bit misleading — the key itself is really just the cipher that's used to scramble and unscramble the data being encrypted.
• With an ancient cipher, like the Caesar cipher, the private key was simply a number that corresponded to the number each alphabetical character needed to be shifted. In current digital encryption schemes, the keys are now prohibitively difficult algorithms that no modern computer could ever efficiently crack.
• The one thing that remains the same with all private key systems is that the same key can both encrypt and decrypt. Private key encryption is sometimes called symmetric encryption.

**worn on a body.** These wearable devices are used for tracking information on real time basis. They have motion sensors that take the snapshot of your day-to-day activity and sync them with mobile devices or laptop computers.

Wearable technology appears prominently in consumer electronics with the popularisation of the smartwatch and activity tracker. Apart from commercial uses, wearable technology is being incorporated into navigation systems, advanced textiles and healthcare. Hearing aid wearable devices are more common and older than the popular smartwatches today.

Even before the wearable technology entered the consumer market, these wearable devices were used in the field of military technology. In fact, these devices were an integral part of the medical and healthcare sector in the military forces. Devices like **'Wearable Motherboards'** or **'Smart Shirts'** used to monitor the health and well-being of the patients and send back information to the hub station on real-time basis.

## 12.12 BIOMETRICS

The measurement and statistical analysis of people's physical and behavioural characteristics comes under Biometrics. The term 'biometrics' is derived from the Greek words 'bio' meaning life and 'metric' meaning to measure. The technology enables identification and access control, or for identification of individuals that are under surveillance. The basic premise and principle that guides biometric authentication is that everyone is unique and hence, an individual can be identified by his or her intrinsic physical or behavioural traits.

The individuals are labelled and described using biometric identifiers, which are the distinctive, measurable characteristics. They are often classified as physiological and behavioural features.

**Physiological characteristics** are those, which are connected to the body shape. Common examples are fingerprint, palm veins, face recognition, palm print, hand geometry, iris recognition, retina and odour/scent. Even DNA is a very important characteristic.

**Behavioural characteristics** relate to the pattern of behaviour of a person, including but not limited to typing rhythm, gait and voice. Some researchers have coined the term behaviour metrics to describe these features.

### *Methods of Biometrics*

A biometric system can be of two types: An 'identification' system and a 'verification' system.

**Identification** – One to Many: A person's identity can be determined using biometrics, even without his knowledge or consent. For example, scanning a crowd with a camera and using face recognition technology, matching against a known database, can be determined, which has become very useful in recent times.

**Verification** A person's identity can be verified using biometrics. For instance, one can grant physical access to a secure area in a building by using finger scans or can grant access to a bank account at an ATM by using retinal scan. Biometric authentication needs to compare a registered or enrolled biometric sample (biometric template or identifier) against a newly captured biometric sample (for example, the one captured during a login). It is a three-step process (Capture, Process and Enrol), after which Verification or Identification process follows.

### *Characteristics of Biometrics*

During the first phase of processing, number of biometric characteristics may be captured. However, that the biometric characteristics should satisfy the following characteristics for automated capturing and automated comparison with previously stored data:

1. **Universal:** The characteristic/attribute should be possessed by everyone and should be such that it is universal and seldom lost to accident or disease.
2. **Invariance of Properties:** They should be constant over a long period of time and not subjected to significant differences on the basis of age, either episodic or chronic diseases.
3. **Measurability:** The properties can be captured with ease and in less time, waiting time and the attribute data can be gathered passively.
4. **Singularity:** Each expression of the attribute must be unique to the individual with sufficient unique properties to distinguish one person from other. Height, weight, hair and eye colour are all attributes that are unique, assuming a particularly precise measure; however, not enough points of differentiation except in categorising usage.
5. **Acceptance:** A large percentage of the population should accept the way to capture. Invasive

technologies, particularly, are excluded because they require a part of the human body to be taken or which (apparently) impair the human body.

6. **Reducibility:** The captured data should be capable of being reduced to an easy-to-handle file.
7. **Reliability and Tamper-Resistance:** The attribute should be practically impossible to mask or manipulate to ensure high reliability and reproducibility.
8. **Privacy:** The process should not violate the privacy of the person.
9. **Comparable:** The attribute can be reduced to a state, which is digitally comparable to others. The less probabilistic the matching involved, the more authoritative the identification.
10. **Inimitable:** The attribute cannot be reproduced by other means. The lesser the reproducibility of the attribute, the more likely it will be authoritative.

### *Uses of Biometrics*

- In Justice and Law enforcement, truly multimodal, fingerprint, face and voice recognition are used.
- In airports, iris recognition is used for passengers.
- In Internet banking, fingerprints are used for employees and customers having high-value transactions.
- In health care, biometrics are used for maintaining valuable records.
- In ATMs, iris recognition is now used for account holders.
- In corporate sectors, fingerprints are used for employees for attendance purpose.
- In examinations, biometrics are used to save candidate's personal details and as well as attendance.

### *Biometrics in India*

India, being perpetually under the threat of terrorism and security breach, is gearing up to adopt various biometric methods.

It is used in higher level of security and authentication:

- In Defence and Security Industry
- In Police Administration
- In Finance Ministry
- In Home Affairs

### *Biometrics India Expo 2007*

From September 13 to 15, 2007, the First International Conference and Exhibition of Biometric Technologies and Applications was held at Pragati Maidan, New Delhi.

## 12.13 FACIAL RECOGNITION TECHNOLOGY

- After a delay of three years, it was expected that by August 31st, 2022, passengers will be able to use a face scan as their boarding pass at four airports in the country but it got launched on 1 December 2022.
- Airports at Varanasi, Pune, Kolkata and Vijaywada will be the first to roll-out the facial recognition technology-based biometric boarding system.
- Thereafter, the technology will be scaled up in a phased manner across various airports in the country.

### *Implementation*

- The Airports Authority of India has engaged NEC Corporation Private Limited for implementing the technology as part of the DigiYatra policy, which seeks to promote paperless air travel and a seamless journey from entering an airport till boarding a plane.
- The policy was unveiled in October 2018, and as per the original plan, the roll-out of the facial recognition technology was scheduled for April 2019.

### *What is facial recognition?*

- Facial recognition is a biometric technology that uses distinctive features on the face to identify and distinguish an individual.
- Automated Facial Recognition System (AFRS) works by maintaining a large database with photos and videos of peoples' faces. Then, a new image of an unidentified person – often taken from CCTV footage – is compared to the existing database to find a match and identify the person.
- The artificial intelligence technology used for pattern-finding and matching is called "neural networks".

### *Benefits of facial recognition*

- Improves outcomes in the area of criminal identification and verification.
- Easy identification amongst crowds.
- Boosts the police department's crime investigation capabilities.

- Helps civilian verification when needed. No one will be able to get away with a fake ID.

*What are the Concerns?*

- Absence of specific laws or guidelines pose a huge threat to the fundamental rights to privacy and freedom of speech and expression because it does not satisfy the threshold the Supreme Court had set in its landmark privacy judgment in the 'Justice K.S. Puttaswamy *vs* Union of India' case.
- Many institutions have not conducted Privacy Impact Assessment prior to deployment of the Facial Recognition System (FRS).
- **Function creep:** A function creep happens when someone uses information for a purpose that is not the original specified purpose (Police got permission to use the FRS by an order of the Delhi High Court for tracking missing children. Now they are using it for wider security and surveillance and investigation purpose, which is a function creep).
- This might lead to an over-policing problem or problems where certain minorities are targeted without any legal backing or any oversight as to what is happening. Another problem that may arise is of mass surveillance, wherein the police are using the FRT system during protest.
- **Mass surveillance:** If someone goes to a protest against the government, and the police are able to identify the person, then there might be repercussions.
- The basis of the AFRS is a Cabinet note of 2009. But the Cabinet note is not a legal substance, it's a procedural note at best. So it does not form a valid legal system based on which the AFRS can be built.

*Need of the hour*

- The Supreme Court in the *Puttaswamy* judgment ruled that privacy is a fundamental right even in public spaces. And if these rights need to be infringed, then the government has to show that such action is sanctioned by law, proportionate to the need for such interference, necessary and in pursuit of a legitimate aim.

## 12.14 DIGITAL LENDING

It consists of lending through **web platforms or mobile apps,** by taking advantage of technology for authentication and credit assessment. **India's digital lending market has seen a significant rise** over the years. The digital lending value increased from USD 33 billion in FY 2015 to USD 150 billion in FY 2020 and is expected to hit the USD 350 billion mark by FY 2023. **Banks** have launched their **own independent digital lending platforms** to tap in the digital lending market by leveraging existing capabilities in traditional lending.

*Significance of Digital Lending*

**Financial Inclusion:** It helps in meeting the huge unmet credit need, particularly in the microenterprise and low-income consumer segment in India.

**Reduce Borrowing from Informal Channels:** It helps in reducing informal borrowings as it **simplifies the process of borrowing**. Indians continue to borrow from family and friends and moneylenders, sometimes at unreasonably high interest rates, primarily because these loans are more flexible and convenient.

**Time Saving:** It decreases time spent on working loan applications in-branch. Digital lending platforms have also been known to **cut overhead costs by 30–50%.**

*Issues with Digital Lending Platforms*

Growing number of **unauthorised digital lending platforms** and mobile applications as:

- They charge **excessive rates of interest and additional hidden charges.**
- They adopt **unacceptable and high-handed recovery** methods.
- They **misuse agreements to access data on mobile phones** of borrowers.
- **Steps Taken by RBI:**
  - **Non-Banking Financial Companies (NBFCs)** and **banks** need to **state the names of online platforms** they are working with.
  - RBI has also **mandated that digital lending platforms which are used on behalf of banks and NBFCs should disclose the name of the Bank(s) or NBFC(s)** upfront to the customers.
  - The Central Bank had also **asked lending apps to issue a sanction letter to the borrower on the letter head of the bank/NBFC concerned** before the execution of the loan agreement.
  - Legitimate public **lending activities can be undertaken by banks, NBFCs registered**

**with the RBI** and other entities who are regulated by state governments under statutory provisions.

- **India's Digital Ecosystem:**
  - Banks have partnered with Fintechs to serve their customers better.
  - Government of India has taken many initiatives such as **Unified Payments Interface, Jan Dhan Yojana, Aadhaar enabled Payment System**, etc., to promote digital environment in the country especially after demonetisation.

India is on the verge of a **digital lending revolution and making sure that this lending is done** responsibly and can ensure the fruits of this revolution are realised. As several players have access to sensitive consumer data, **there must be clear guidelines around, for example, the type of data that can be held, the length of time data can be held for and restrictions on the use of data.**

Digital lenders should proactively develop and commit to a **code of conduct that outlines the principles of integrity, transparency and consumer protection,** with clear standards of disclosure and grievance redressal. An **agency can be created that tracks all digital loans and consumer/lender credit history.** Apart from establishing technological safeguards, **educating and training customers to spread awareness about digital lending is also important.**

## DIGITAL SIGNATURE

A Digital Signature means an electronic signature, useful to authenticate the identity of the sender of a message or the signer of an electronic document. This ensures that the original content of the document is not changed. Digital signatures are advantageous, as they are easily transportable, cannot be imitated by someone else and can be automatically time-stamped. The sender cannot easily repudiate it later, which ensures that the original signed message is received.

Certain types of encryptions make digital signature effective to ensure authentication. Encryption takes all the data that one computer is sending to another and encodes it into a form that only the other computer will be able to decode. Authentication verifies that information is coming from a trusted source. These two processes work hand-in-hand for digital signatures.

### *How does It work?*

Let us say, you are going to send the draft of a contract to your lawyer in another town. To assure your lawyer that it is unchanged from what you have sent and that it is really from you, this is how you proceed with the process:

1. Copy-and-paste the contract into an email note.
2. By using special software, you obtain a message hash (mathematical summary) of the contract.
3. You then use a private key that you have previously obtained from a public–private key authority for encryption of hash.
4. The encrypted hash acts as your digital signature of the message. (Note: It will be different each time you send a message.)

### *At the other end, your lawyer receives the message*

1. To make sure it is intact and from you, a hash is made by your lawyer, of the received message.
2. Your lawyer then uses your public key to decrypt the message hash or summary.
3. The received message is valid only if the hashes match.

### *Significance*

Just like a handwritten signature authenticates printed documents, a digital signature authenticates electronic documents; hence, this signature cannot be forged and it asserts that a named person wrote or otherwise agreed to the document, which attaches that signature. On the whole, digital signatures enable the 'authentication' and 'non-repudiation' of digital messages, which assures the recipient of a digital message in terms of both, identity of the sender and the integrity of the message.

A Certification Authority (CA) issues a digital signature, which is signed with the CA's private key. A digital signature typically contains the: Owner's public key, the owner's name, expiration date of the public key, the name of the issuer (the Certification Authority that issued the Digital ID), serial number of the digital signature and the digital signature of the issuer.

### *Legal in India*

India is among those few nations that have the Digital Signature Legislation. This Act grants digital signatures (issued by the Licensed Certifying Authority in India) the same status as a physical signature. Digital signatures deploy the Public Key Infrastructure (PKI) technology.

**The Procedure of Checking the Validity of Digital Signature:**

- A signed document is sent from User A to User B.
- For verification of the signature on the document, User B's application first uses the certificate authority's public key to check the signature on User A's certificate.
- When the certificate is successfully de-encrypted, it proves that the certificate authority created it.
- After the de-encryption of certificate, User B's software can check if User A is in good standing with the certificate authority. Additionally, it checks that all of the certificate information concerning User A's identity has not been altered.
- User B's software then takes User A's public key from the certificate for checking User A's signature. If User A's public key de-encrypts the signature successfully, then User B is assured that the signature was created using User A's private key, because the certificate authority has certified the matching public key.
- Once the signature is found valid, it implies that an intruder did not try to change the signed content.

***Digital Signatures vs. Digital Certificates***

A Digital Signature is an electronic method of signing an electronic document whereas a Digital Certificate is a computer-based record which:

- Identifies the Certifying Authority issuing it.
- Has the name or the identity of its subscriber.
- Contains the subscriber's public key.
- Is digitally signed by the Certifying Authority issuing it.

So, digital signature is not a record, and the identification of certifying authority is ascertained from the digital certificate, not digital signature.

A digital certificate is a form of an electronic credential for the Internet. Similar to a driver's licence, employee ID card, a digital certificate is issued by a trusted third party to establish the identity of the certificate holder. The third party who issues the digital certificate is known as the Certifying Authority (CA).

- **Digital Signatures** provide Authentication, Privacy, Non repudiation and Integrity in the virtual world. IT Act 2000 in India gives legal validity to electronic transactions that are digitally signed. Therefore, we need digital signatures for secure messaging, online banking applications, online workflow applications, e-tendering, supply chain management, etc.
- **Digital Certificates** are digital documents attesting to the binding of a public key to an individual or specific entity. They allow verification of the claim that a specific public key does, in fact, belong to a specific individual. Digital certificates help to prevent someone from using a phony key to impersonate someone else.

## 12.16 GOOGLE's PROJECT DRAGONFLY

Development of the programme, project 'Dragonfly', started in early 2017 and was accelerated following a meeting between Google's CEO and top Chinese government officials in late 2018.

- **Dragonfly (search engine):** Dragonfly was **an Internet search engine app being prototyped by Google** that was ***designed to be compatible with China's state censorship provisions.***
- Google's search service cannot now be accessed by most of the Internet users in China because it is blocked by the country's so-called ***Great Firewall.*** The app Google is building for China will comply with the country's strict censorship laws, restricting access to content that Xi Jinping's Communist Party regime deems unfavourable.
- Doing business in China is good for shareholders, bad for humanity.
- It's profitable. With its population at 1.3 billion, China has the largest number of Internet users in the world, so breaking into the Chinese market has been a long-time goal for Silicon Valley tech giants in their quest to find new users and to grow profits.
- But working in China inevitably raises ethical issues for any US company. Doing business in mainland China means making deals with an authoritarian government that has a record of human rights abuses and a strict suppression of speech.

***What's the Issue?***

- Google's China project has been highly contested from the beginning, as the company is said to be aiding censorship and surveillance – effectively adding to the country's human rights violations.

- The internal dispute mainly revolved around a Beijing-based website, 265.com, which Google purchased back in 2008. The company used the site for market research.

## 12.17 EDGE COMPUTING

According to a research, by 2025, companies will generate and process more than 75% of their data outside of traditional centralised data centres – that is, ***at the 'edge' of the cloud.*** As the use of ***Internet of Things (IoT)*** devices expands and the need to process IoT data quickly increases, many IT leaders are considering or beginning to employ ***edge computing*** options.

### *What is Edge Computing?*

Edge Computing ***enables data to be analysed, processed and transferred at the edge of a network. Meaning, the data is analysed locally,*** closer to where it is stored, in real-time without latency, rather than sending it far away to a centralised data centre.

It allows for quicker data processing and content delivery.

### *How is Edge Computing Different from Cloud Computing?*

- The basic difference between edge computing and cloud computing lies ***in where the data processing takes place.***
- ***Internet of Things (IoT)*** systems perform all of their computations ***in the cloud using data centres.***
- In ***Edge Computing,*** massive amounts of data generated by IoT devices are stored and processed locally. ***That data doesn't need to be sent over a network as soon as it processed; only important data is sent*** – therefore, an edge computing network reduces the amount of data that travels over the network.

### *Challenges*

According to experts, ***edge computing introduces several new security risks.***

1. One of the most prominent concerns is the physical security of the devices, which are more vulnerable to malicious attacks and mishaps of all kinds than typical office equipment and technology safely held within corporate walls.
2. ***Micro data centres,*** such as those being deployed by telecommunication companies – in some cases, at the base of cell towers-introduce a level of physical vulnerability that didn't exist with corporate data centres and large cloud providers.
3. Meanwhile, ***many organisations will be challenged to understand, track and monitor what data they have and where, what protections are required at the various points based on the data and vulnerabilities specific to each endpoint and how to govern what could soon be a sprawling infrastructure at many companies.***

### *Benefits*

- Edge computing may ***offer some protection against a catastrophic attack where a single incident can compromise large amounts of a company's data.***
- In some ways, ***it's more resilient, because instead of one or two or even three data centres,*** you have distributed data and compute on the edge, which makes it much more resilient to malicious and nonmalicious events.

### *Way Ahead*

- Experts believe the true potential of edge computing will become apparent when 5G networks go mainstream in a year from now. Users will be able to enjoy consistent connectivity without even realising it.

## 12.18 SPACE INTERNET

### 12.18.1 Starlink Project

***SpaceX,*** the world's leading private company in space technology, has launched 60 satellites into ***the low earth orbit,*** under the ***Starlink Network Project.***

### *What is It?*

- The Starlink network is one of several ongoing efforts to ***start beaming data signals from space.***
- Under the project, the company intends ***to evolve into a constellation of nearly 12,000 satellites.***
- The aim is ***to provide low-cost and reliable space-based Internet services to the world.***
- The project was announced in 2015.

### *Significance of the Project*

- The project ensures that reliable and uninterrupted Internet services are universally available in every part of the globe.

- About 4 billion people, more than half of the world's population, do not have access to reliable Internet networks.
- This is because ***the traditional ways to deliver the Internet – fibre-optic cables or wireless networks – cannot take it everywhere on Earth.***
- In many remote areas or places with difficult terrain, it is not feasible or viable to set up cables or mobile towers.
- ***Signals from satellites*** in space can overcome this obstacle easily.

### *Why Should We Use Low Earth Orbit Instead of Geostationary?*

- Geostationary orbit is ***located at a height of 35,786 km over the Earth's surface***, directly above the Equator. Satellites in this orbit move at the speed of about 11,000 km per hour and complete one revolution of the Earth in the same time that the earth rotates once on its axis. To the observer on the ground, therefore, a satellite in geostationary orbit appears stationary.

### *Advantages*

- Signals from geostationary orbit can cover a very large part of the Earth. Signals from one satellite can cover roughly a third of the planet – and three to four satellites would be enough to cover the entire Earth. Also, because they appear to be stationary, it is easier to link to them.

### *Then What's the Issue?*

- There is ***a time lag – called latency*** – between a user seeking data and the server sending that data.
- Data ***transfers cannot happen faster than the speed of light*** (in reality, they take place at significantly lower speed), the longer the distance that needs to be covered the greater is the time lag or latency.
- A transmission from a ***satellite in geostationary orbit has a latency of about 600 milliseconds.***

### *How Does Low Earth Orbit Seek to Solve This Issue?*

- A satellite in the lower orbit, 200–2,000 km from the Earth's surface, can bring the lag down to 20–30 milliseconds, roughly the time it takes for terrestrial systems to transfer data.

### *Concerns over LEOs*

- Owing to their lower height, ***their signals cover a relatively small area.*** As a result, many more satellites are needed in order to reach signals to every part of the planet.
- ***Other issues include:*** Increased space debris, increased risk of collisions and the concern of astronomers that these constellations of space Internet satellites will make it difficult to observe other space objects and to detect their signals.

### *Challenges*

- LEO satellites travel at a speed of 27,000 kph and complete a full circuit of the planet in 90–120 minutes. As a result, **individual satellites can only make direct contact with a land transmitter for a short period of time,** thus requiring massive LEO satellite fleets and consequently, a significant capital investment.

### *Criticisms of LEO satellites*

- **The balance of power has shifted from countries to companies,** since most of these are projects run by private companies. As a result, there are questions related to who regulates these companies, especially given the myriad of nations that contribute to individual projects.
- Complicated regulatory framework.
- Stakeholders in these companies are from various countries. Thus, it becomes challenging to receive requisite licences to operate in each country.
- Satellites can sometimes be seen in the night skies which creates **difficulties for astronomers** as the satellites reflect sunlight to earth, leaving streaks across images.
- Satellites travelling at a lower orbit can also **interrupt the frequency of those orbiting above them.**
- Those objects, colloquially referred to as **'space junk,'** have the potential to damage spacecraft or collide with other satellites.

## 12.18.2 OneWeb: Internet

OneWeb has a partnership formed with debris-removal start-up Astroscale under **ESA's Sunrise program.**

### *About OneWeb's LEO internet programme:*

- **OneWeb is a Low Earth Orbit (LEO)** satellite communications operator.
- Using LEO satellites OneWeb seeks to offer connectivity across **the UK, Alaska, Northern**

**Europe, Greenland, the Arctic Seas and Canada.** The company expects the service to be switched on before the end of this year.

- It calls this programme the **'Five to 50' service** of offering internet connectivity to **all regions north of 50 degrees latitude.**

*Potential*

- LEO satellite broadband is preferable in areas that cannot be reached by fibre and spectrum services. The target market will therefore be rural populations and military units operating away from urban areas.
- OneWeb's chief competitor is **Starlink**, a venture led by Elon Musk's SpaceX. Starlink currently has 1,385 satellites in orbit and has already started beta testing in North America and initiating pre-orders in countries like India.

### Jio Platforms to Provide Satellite Broadband Services

- Jio has formed a joint-venture with Luxembourg-based SES to deliver satellite broadband services across India.
- The joint venture will use **multi-orbit space networks** that is a combination of GEO **(geostationary equatorial orbit) and MEO (medium earth orbit) satellite constellations** capable of delivering multi-gigabit links and capacity to enterprises, mobile backhaul and retail customers across the length and breadth of India and neighbouring regions.

***How is this different from what Starlink or OneWeb offers?***

- SES primarily has satellites in the GEO and the MEO, while those of Elon Musk-led Starlink and Bharti Group's **OneWebare** in **low earth orbit (LEO).**
- While **GEO satellites are positioned at an altitude of 36,000 km, MEO and LEO are lower at altitudes of 5,000–20,000 km and 500–1,200 km,** respectively.
- **The altitude of the satellite is directly proportional to the area of earth that it covers.** Therefore, the higher a satellite is positioned, the larger an area it covers.

## 12.19 VIRTUAL REALITY (VR) AND AUGMENTED REALITY (AR)

*Virtual Reality*

Virtual Reality or Virtual Realities (VR) is/are also called as immersive multimedia or computer-simulated reality. It is a computer technology replicating an environment, real or imagined, wherein, a user's physical presence and environment are simultaneously with user interaction.

- Virtual realities artificially create the experience of senses, including sight, touch, hearing and smell.
- Either a computer screen or a special virtual reality headset (head mounted display) display the most up-to-date virtual realities. Some simulators consist of additional sensory information and focus on real sounds with the help of speakers or headphones.
- Currently, some advanced haptic systems consist of physical information, which is usually termed as force feedback in applications of medical, gaming and military.
- Through the usage of standard input devices like keyboard and mouse or with the help of multimodal devices, such as a wired glove or omnidirectional treadmills, there is coverage of the remote communication environments, thereby enabling the user's virtual presence by deploying the telepresence and telexistence concepts or a virtual artefact. The mesmerising environment can be similar to the real world in order to create a real type experience which can be beneficial in cases like pilot or combat training simulations.

*Augmented Reality*

- **Augmented Reality (AR)** is a live direct or indirect view of a physical, real-world environment. The elements of AR are augmented (or supplemented) by computer-generated sensory input like sound, video, graphics or GPS data.
- It is related to a more general concept called mediated reality, in which modification is done by computer as a view of reality. Consequently, the technology enhances one's current perception of reality. Contrary to this, virtual reality replaces the real world with a simulated one.

- Augmentation by convention is in real time and in semantic context with environmental elements. The examples include sports scores on TV during a match.
- The real world is overlaid with information about the environment and its objects. This can be virtual or real, such as seeing other real sensed or measured information, such as the over lading of electromagnetic radio waves in correct alignment with where they actually are in space.

*Applications*

- **Health Care:** Virtual reality exposure therapy (3-dimensional computer simulation), when combined with physiological monitoring and feedback, enables treatment of panic and anxiety disorders.
- **Education Sector:** Education sector has adopted virtual reality for teaching and learning situations. It is advantageous because it enables large groups of students to interact with each other; in fact, within a three-dimensional environment.
- **Tourism:** Tourism is another industry in the use of virtual reality, i.e., in museums and historical places. These settings employ interaction for communicating information to the general public in new and exciting ways.
- **Other Sets of Applications are:** Business, engineering, sports, media, military and scientific visualisation.

(Refer Infographic – VR/AR/MR & AR)

## 12.20 METAVERSE

Metaverse is a portmanteau of meta, meaning transcendent, and verse, from universe.

The metaverse is a network of always-on **virtual environments in which many people can interact with one another** and **digital objects while operating virtual representations** or avatars of themselves.

Think of a combination of immersive virtual reality, a massively multiplayer online role-playing game and the web.

Metaverse is a successor of today's internet. It's only a vision at this point, but technology companies like Facebook are aiming to make it the setting for many online activities, including work, play, studying and shopping.

If we have to answer the question – what is metaverse, it could be answered with the help of three key aspects – presence, interoperability and standardisation.

**Presence** is the feeling of being in a virtual space, with virtual others. It will improve the quality of online interactions. This sense of presence is achieved through virtual reality technologies such as head-mounted displays.

**Interoperability** means being able to seamlessly travel between virtual spaces with the same virtual assets, such as avatars and digital items. Zoom meetings through apps like Animaze, blockchain technologies such as cryptocurrencies and non-fungible tokens facilitate the transfer of digital goods across virtual borders.

**Standardisation** is what enables interoperability of platforms and services across the metaverse. International organisations such as the Open Metaverse Interoperability Group define these standards.

## 12.21 DNA COMPUTER

DNA computing is a branch of computing, which uses DNA, biochemistry and molecular biology hardware, in place of the traditional silicon-based computer technologies. Research and development in this area is concerned with theory, experiments and applications of DNA computing.

The term 'molectronics' has sometimes been used; however, it was already used for an earlier technology, a then-unsuccessful rival of the first integrated circuits. This term has also been used for molecular-scale electronic technology, more generally.

The potential of DNA-computer to make a high amount of multiple parallel computations at a high speed compensates its slow processing speed (the response time is measured in minutes, hours or days, and not in milliseconds). Thus, it enables the system to consume similar amount of time for a complex calculation as for a simple one.

This is achieved considering that millions or billions of molecules interact with each other simultaneously. However, the analysis of the answers, given by a DNA-computer is much harder as compared to a digital one.

# VR (VIRTUAL REALITY)

It involves a computer-generated 3D environment that can be explored and interacted with by individuals. When engaging in VR, users become immersed in this virtual world and are often able to manipulate objects and carry out various actions. Head-Mounted Devices (HMD) like Oculus Rift, HTC Vive, and Google Cardboard are commonly used by many to experience VR.

**USERS**

One Device Per User

**ENVIRONMENT**

Completely Digital Environment (Indoors only)

**EXPERIENCES**

Fully enclosed, synthetic experience with no sense of the real world

## ADVANTAGES

1. In engineering, for example, Virtual Reality (VR) provides an effective means of demonstrating products and services, allowing clients to visualize outcomes and gain a better understanding of the final results.
2. Manufacturers can experience products before they commit to producing them.
3. Virtual prototyping enabling them to fine-tune designs and troubleshoot earlier in the development process.
4. In training, VR is having a marked impact across a large number of sectors, including medical, aerospace, military and sport.
5. It offers opportunities for iterative learning and repeated exercises in highly realistic, challenging environments.
6. VR also provides highly accurate, walk-through visualizations of architectural projects and renovations.

# AR (AUGMENTED REALITY)

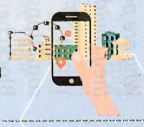
AR, unlike VR, does not offer full immersion. It involves adding digital elements to a live view using smartphone or tablet cameras. Examples of AR experiences and games include popular apps like Pokémon Go and Snapchat Lenses.

**USERS**

Information can be viewed by Multiple Users Simultaneously

**ENVIRONMENT**

Real world with digital information overlay (Indoor and Outdoors (Best Outdoors))



**EXPERIENCES**

Real world remains central to the experiences, enhanced by virtual details.

## ADVANTAGES

1. AR provides a richer user experience while providing a cost-effective alternative to other media platforms
2. AR has a range of important practical applications across different industries.
3. It is especially well-suited to the massively expanding smartphone market, integrating its technology into highly personal and mobile experiences.
4. In the automotive sector, it is used with in-car dashboards to provide drivers with useful and essential travel and technical information.
5. AR provides virtual instructions for tasks like checking tyre pressure and performing oil changes, allowing users to follow step-by-step guidance using digital overlays.
6. In both education and tourism, AR can add extra layers of information to historical and cultural sites for users, experienced in real time on location.
7. For customers in the financial and banking sector, there are AR-activated bank cards and geo-targeting apps for locating nearby banking facilities.

# MR (MIXED REALITY)

Mixed Reality (MR) is a technology that merges aspects of both Augmented Reality (AR) and Virtual Reality (VR). In MR, physical and digital objects coexist and interact in real-time, enabling users to engage with a blend of virtual and real-world elements.

**USERS**

Information can be viewed by Multiple Users Simultaneously

**ENVIRONMENT**

Real and Virtual Environment intertwined(Indoor and Outdoors (Best Indoors))

**EXPERIENCES**

Interaction with and manipulation of both the physical and virtual environment

## ADVANTAGES

1. Call-out engineers can use Mixed Reality for accessing up-to-date information and support from remote experts while remaining hands-free to apply this knowledge practically on-site.
2. It can also speed up the training process, helping businesses bridge the skills gap.
3. Remote experts offer over-the-shoulder coaching to employees and operatives in the field through hands-free MR devices.
4. MR enables intensive on-the-job training, combining practical instruction with digital information.
5. MR is changing how people work, learn and live, and it has the potential to expand further to improve and enhance enterprises and organisations.
6. Quality controllers in manufacturing can overlay information from head mounted displays (HMDs) and hand held devices, speeding up quality assurances processes and reducing errors.

# XR (EXTENDED REALITY)

The term 'Extended Reality' (XR) refers to the combination of computer-generated environments and interactions that integrate elements from both the real and virtual worlds. XR encompasses technologies such as Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR).

**USERS**

Information can be viewed by Multiple Users Simultaneously

**ENVIRONMENT**

Information can be viewed by Multiple Users Simultaneously

**EXPERIENCES**

It seamlessly combines digital elements with the real world, offering users an immersive and interactive experience.

## ADVANTAGES

1. In Education and Training, XR bridges the gap between educators and trainees, enabling closer collaboration even when people attend courses remotely.
2. XR can accelerate learning helping companies save money on training.
3. It provides safe learning environments where trainees can learn from mistakes without any risks.
4. XR offers detailed analytics, connected to performance and interaction, which support rigorous assessment, testing and refinement of marketing messages.
5. Consumers can experience and visualize goods before making any physical purchase.
6. Providing immersive experiences is enabling brands to improve how they market products, bringing customers closer into their world.
7. For presentation and collaboration, XR enables shared, large-scale visualization and vivid, walk-through representations of designs structures.

## 12.22 OPTICAL COMPUTER/PHOTONIC COMPUTER

An optical computer (also called a photonic computer), as a device, uses the photons of visible light or infrared (IR) beams, instead of electrons in the electric current, to perform digital computations.

The transistor (which functions as an electronic switch) is the fundamental building block of modern electronic computers. It can be turned 'off' or 'on' by varying the input voltage. This way, digital data can be represented as '1' for 'on' and '0' for 'off'.

Optical computers require equivalent 'optical transistors', which is achieved by using materials with a 'non-linear refractive index'. In such materials, the intensity of incoming light affects the intensity of the light transmitted through the material, just like the voltage response of an electronic transistor. This 'optical transistor' effect is useful for data storage and creation of logic gates, which in turn, get assembled into the higher-level components of the computer's CPU.

### *Advantages*

- Theoretically, as compared to today's computer, we can produce computers, which are thousands of times faster, by the application of optical computing. This is due to the fact that light can travel much faster than electric current.
- It could also increase the speed of communication systems, bringing high bandwidth, low cost optical communications.
- Because of the fewer requirements of wires, optical computers could be much smaller. Smaller computers consume lesser energy.
- However, there are enormous technical hurdles which should be overcome before a practical optical computer can be made. Currently, most of the research projects focus on replacing current computer components with optical equivalents. As a result, a hybrid optical-digital computer system can be developed. Through this approach, we can achieve the best short-term prospects for commercial optical computing. In 2018, Intel unveiled a prototype hybrid optical-digital device that can transfer data at 50 gigabits per second.

## 12.23 NON-FUNGIBLE TOKENS (NFT)

Revenue in the NFT market is projected to reach US$1,601.00m in 2023. Revenue is expected to show an annual growth rate (CAGR 2023-2027) of 18.55% resulting in a projected total amount of US$3,162.00m by 2027. The average revenue per user in the NFT market amounts to US$114.80 in 2023. As the crypto asset exploded in popularity, fuelled by the rising interest of celebrities and tech evangelists. Some experts believe NFTs are a bubble which might pop.

### *Features*

- NFT can be anything that can be converted into a digital form.
- Everything from drawings, photos, videos, GIF, music, in-game items, selfies, and even a tweet can be turned into an NFT, which can then be traded online using cryptocurrency.
- NFTs are unique from other digital forms as it is backed by Blockchain technology.
- NFTs are gaining massive popularity now because they are becoming an increasingly popular way to showcase and sell your digital artwork.

### *Why are people willing to spend millions on something they could easily screenshot or download?*

When NFT is listed on a marketplace, you need to pay something called a gas fee (transaction fee) for using the Blockchain, following which digital art is then recorded on Blockchain, mentioning that you (your address) own the particular NFT.

This gives you full ownership, which cannot be edited or modified by anyone, including the marketplace owner. An NFT is thus created to get exclusive ownership rights. NFTs can have only one owner at a time.

Apart from exclusive ownership, NFT owners can also digitally sign their artwork and store specific information in their NFTs metadata which will only be viewable to the individual who bought the NFT.

### *Working mechanism of NFTs*

NFT works on blockchain as it gives users complete ownership of a digital asset. For example: consider a sketch artist who converts digital asset to an NFT what he gets in return is proof of ownership, powered by Blockchain.

### *Blockchain Technology*

A blockchain is a digital ledger of transactions that is duplicated and distributed across the entire network of computer systems on the blockchain.

Each block in the chain contains a number of transactions, and every time a new transaction occurs on the blockchain, a record of that transaction is added to every participant's ledger. In short, here the transactions are transparent and can be seen by anyone and cannot be changed or modified once recorded.

### *Cryptocurrency*

Cryptocurrency also called "crypto" is any form of currency that exists digitally or virtually and uses cryptography to secure transactions. Cryptocurrencies does not have a central issuing or regulating authority. It instead uses a decentralised system to record transactions and issue new units.

It's a peer-to-peer system that can enable anyone anywhere to send and receive payments.

### *NFT vs. Cryptocurrency*

NFTs and cryptocurrencies are very different from each other. The only similarity is that both are built on Blockchain.

Cryptocurrency is a currency which is fungible meaning that it is interchangeable. For instance, if you hold one crypto token, say one Ethereum, the next Ethereum that you hold will also be of the same value.

While NFTs are non-fungible that means the value of one NFT is not equal to another. Every art is different from other, making it non fungible, and unique.

### *Who can buy NFTs?*

- Anyone who holds a cryptocurrency wallet can buy an NFT.
- That is the only prerequisite to purchase an NFT.
- No need of any KYC documents to purchase an art.
- All that is needed is a cryptocurrency wallet powered by Metamask, and an NFT marketplace where you can buy and sell NFTs.

### *Risks associated with NFTs*

- Several incidents of NFT scams like emergence of fake marketplaces, unverified sellers often impersonating real artists and selling copies of their artworks for half prices.
- Also sharing of potential phishing link leading to draining of cryptocurrency wallet.
- Hacking of NFT's is another potential threat which can leave you bankrupt.
- It also negatively impact the environment in order to validate transactions crypto mining is done, which requires high powered computers that run at a very high capacity, affecting the environment ultimately.

[Refer **Infographic – Non Fungible Token (NFT)**]

## 12.24 TRADITIONAL KNOWLEDGE DIGITAL LIBRARY (TKDL)

TKDL is an Indian digital knowledge repository of traditional knowledge, especially dealing with medicinal plants and formulations used in Indian systems of medicine. TKDL was established with the collaboration of the Council of Scientific and Industrial Research (CSIR) and the Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (Department of AYUSH), the Ministry of Health and Family Welfare, Government of India, in 2001. It aims at shielding the country's ancient and traditional knowledge from the exploitation of bio-piracy and unethical patents, by electronically documenting and characterising it, as per the patent systems of international classification. In addition to this, the non-patent database based on the traditional knowledge serves in the promotion of modern research, which eventually helps in the simplification of the naturopathy's vast knowledge access, including those of traditional remedies or practices.

**Background** In the late 1990s, subsequent to the granting of patents of turmeric and basmati rice by United States Patent and Trademark Office (USPTO) and the neem patent granted by European Patent Office (EPO), respectively, the Indian Government successfully achieved their repudiation. Thereafter, the biopiracy and unethical bioprospecting issue made headlines. This led to coming of more number of patent claims. Due to the existence of India's vast traditional medicine knowledge in languages such as Sanskrit, Hindi, Arabic, Persian, Urdu and Tamil, it became impossible for patent examiners for the verification of such claims at the International patent offices. Thus,

# NFTs (NON-FUNGIBLE TOKENS)

## What are NFTs?

1. Non-Fungible Tokens (NFTs) are digital assets that represent ownership or proof of authenticity of a unique item or piece of content.
2. NFTs are built on blockchain technology, which is a decentralized and transparent digital ledger that records transactions across multiple computers or nodes.
3. Each NFT has a unique identifier that distinguishes it from other tokens, making it indivisible and non-interchangeable.
4. NFTs can represent various digital and tangible items, including artwork, music, videos, virtual real estate, collectibles, and more.
5. NFTs provide a way to prove ownership, provenance, and scarcity of digital assets, which has been a challenge in the digital world.
6. The ownership and transaction history of NFTs are recorded on the blockchain, ensuring transparency and immutability.
7. NFTs are typically bought, sold, and traded on specialized online marketplaces or platforms that support blockchain-based assets.
8. When an NFT is sold, the ownership transfer is recorded on the blockchain, and the seller receives the proceeds from the sale.
9. NFTs can enable creators and artists to monetize their digital work directly, by selling their creations and receiving a portion of subsequent sales through royalties.
10. The value of an NFT is primarily determined by factors such as the perceived value of the underlying content, the reputation of the creator, and market demand.
11. NFTs have gained significant attention and popularity in recent years, with high-profile sales and collaborations involving artists, musicians, athletes, and celebrities.
12. However, it's important to note that the NFT market has experienced both significant successes and speculative trends, and caution should be exercised when participating in this emerging space.

## How to Buy and Sell NFT?

To buy and sell NFTs:

1. Choose an NFT marketplace.
2. Set up a digital wallet that supports NFT transactions.
3. Fund your wallet with cryptocurrency.
4. Browse the marketplace and select the NFT you want to buy.
5. Place a bid or make an immediate purchase.
6. Once purchased, the NFT will be transferred to your wallet.
7. To sell an NFT, list it on the marketplace with a desired price.
8. Once a buyer purchases your NFT, it will be transferred to their wallet.
9. You will receive payment in cryptocurrency to your wallet.
10. Remember to consider transaction fees and research the marketplace and NFT's value before buying or selling.

## Business Value of NFT

NFTs have proven to be a valuable tool in the new digital economy of Web3 and are set to play a fundamental role in the Metaverse. Although their origins lie primarily in art and gaming, NFTs possess the potential to find utility across a wide range of industries. By leveraging blockchain technology to establish verifiable ownership of digital assets, NFTs confer additional value to these assets, which can appreciate over time. A well-executed NFT launch can enhance a business's brand value, but it is essential to handle such launches professionally to avoid potential negative consequences.

## Risks related to NFTs

Prior to acquiring an NFT, it is essential to assess its price history and performance. Platforms like nftgo.com can be utilized to analyze past sales and price trends. It is crucial to recognize that while a few NFTs may experience significant value appreciation, many others may face depreciation or become worthless. Conducting thorough research on the potential risks and rewards associated with investing in NFTs is highly advisable.

the Department of AYUSH, Government of India was encouraged for the creation of TKDL in 2001.

**Achievements** Till 2010, TKDL had transformed 148 number of books in public sphere based on Ayurveda, Unani, Siddha and Yoga languages into the information consisting of 34 million pages and further translating them into five languages, namely, English, German, French, Spanish and Japanese. Moreover, TKDL already received information on Ayurveda's 80,000, Unani's 1,000,000 and Siddha's 12,000 formulations.

TKDL also signed an agreement with the world's leading international patent offices, such as the European Patent Office (EPO), the United Kingdom Trademark and Patent Office (UKPTO) and the United States Patent and Trademark Office (USPTO). Such agreements are signed with a primary objective in the protection of conventional knowledge from biopiracy and further giving access to the database of TKDL by the patent examiners at the International Patent Offices for enabling the purpose of patent search and examinations.

## 12.25 CRYPTOGRAPHY

Cryptography is defined as a process of converting ordinary plain text into unintelligible text and vice-versa. Through this method, the data can be stored and transmitted in a particular form that can be read and processed by only those for whom it is intended. Cryptography protects data from theft or alteration and in addition, can also be used for user authentication.

Earlier, cryptography was effectively synonymous with encryption but nowadays, it is mainly based on computer science practice and mathematical theory.

- Internet communication could be secure or insecure, depending upon the technique used for transmitting digital information over the network.
- With the advancement of Information Technology, most of the information, be it private information

or public information, is being transmitted with high speed and frequency.

- But, is it secure? There have been frequent cases of data theft and information leaks.
- Cryptography is an encoding technique of communication where the actual message is encrypted into unreadable format using various algorithms. This text is called cipher text.
- It is then sent over the network. Even if someone sniffs and intercepts the message, they will not be able to interpret the exact meaning of the text.
- The receiver receives the message and decrypts the information into plain text.
- There are two broad techniques of implementing cryptography: Symmetric key technique and Public key technique.
- Cryptography implements the different aspects of information security including data confidentiality, data integrity, authentication and non-repudiation.

***Application***

- It is now used in our day-to-day actions like Internet banking, ATM transaction, and online shopping.
- Our email communication is encrypted.
- Personal chats and messaging systems like WhatsApp, Facebook messaging are also encrypted.

Cryptography is used in many applications like banking transactions, cards, computer passwords and e-commerce transactions.

## 12.26 DIGITAL INDIA INITIATIVE

Government of India launched Digital India campaign for the availability of the Government services electronically to the citizens through the improvisation of online infrastructure and enhancing the Internet connectivity. It also aims to make the country digitally empowered in the technology field. DeITY or Department of Electronics and Information Technology is an umbrella organisation, which cooperates and coordinates implementation of this programme. All the digital initiatives are like National Broadband Plan and Domestic Manufacturing Policy are integrated and brought under this initiative.

Prime Minister Narendra Modi launched Digital India on 01 July 2015. The initiative involves the strategy of linking rural areas with the network of high-speed Internet. Its three core components are:

1. Creating digital infrastructure
2. Service delivery in digital manner
3. Digital literacy

Through this, Government of India expects growth on multiple fronts. Specifically, the nine 'Pillars of the Digital India' as identified and targeted by GOI are:

- Broadband Highways
- Universal Access to Internet
- Public Internet Access Programme
- e-Governance Reforming Government through Technology
- eKranti – Electronic Delivery of Services
- Information for All
- Early Harvest Programme
- IT for Jobs
- Electronics Manufacturing

Undoubtedly, it is one of the grandest projects till date, embracing all the government machinery and departments in its fold. It primary aim is to create a truly participatory democracy with the application of digital technology. Other targets include connecting more than 120 crore Indians with their government so that they could avail services and benefits of government services in realtime and also get quick grievance redressal.

***The Vision of Digital India***

- Infrastructure development that would enable each and every citizen to utilise it to the fullest. Some of these infrastructures include high-speed Internet facilities, digital identity, mobile and phone banking and safe and secure cyber space.
- Governance and online services that citizens can use to avail services, which remain away from their reach. Some of the facilities include digital support system, services available in real time, services that can enable ease-of-doing business, electronic and cashless financial transactions.
- Digital Empowerment of Citizens: Only digital literacy can harness the benefits of digitisation. Some of the steps would be universal accessibility of digital resources and regional compatibility of digital resources.

### *Challenges in the Implementation of Digital India*

However, implementation of this scheme stands as a great challenge before the government;

**Firstly** connecting 2,50,000 Gram Panchayats through National Optical Fibre Network is not easy in any manner and hence, will require a lot of efforts and dedication from BSNL, the nodal agency that lays down the cables in India.

**Secondly**, IT literacy needs huge improvement, which is again a great task ahead because the project can succeed only when masses know how to utilise the digital services.

**Thirdly**, security of data is mandatory as digital medium is still very unsafe and data vulnerability is a big issue, especially during financial transactions.

**Lastly**, creation of awareness and knowledge about Digital India scheme and its benefits among common masses is also a great challenge, considering high population of India.

**Overall**, great efforts are required from the entire government machinery and people concerned for the success of this project.

## 12.27 TELEMEDICINE

The communications and information technology usage in delivering clinical care is termed as Telemedicine. It is a rapidly developing application of clinical medicine, which transfers medical information through interactive audio-visual, media over a distance. The primary aim of telemedicine is consultation, and sometimes, remote medical procedures or examinations.

Telemedicine is the interaction between patient and doctor without physically facing each other through a medium of communication.

- The medium of communication is usually IT and telecommunication networks.
- Health care facilities like consultation, diagnosis, status report, report analysis, etc., can be provided through it.

At times, the terms 'e-health' and 'telehealth' are wrongly interchanged with telemedicine. Similar to the terms 'medicine' and 'health care', telemedicine often refers only to the provision of clinical service. On the contrary, telehealth can refer to clinical as well as non-clinical services, including medical education, administration, and research; while e-health, particularly in the UK and Europe, is used as an umbrella term including telehealth, electronic medical records and other components of health IT.

### *Types of Telemedicine*

The three main categories of telemedicine are as follows:

- **Store-and-forward telemedicine** implies acquiring medical data (like medical images, bio signals, etc.), which is later transmitted to a doctor or a medical specialist for offline assessment at a convenient time. Both parties are not required simultaneously. The common specialities that are conducive to asynchronous telemedicine include dermatology, radiology and pathology. For this transfer, a properly structured Medical Record (preferably in electronic form) is required.
- **Remote monitoring** or self-monitoring/testing is a technology enabling medical professionals to monitor a patient remotely using various technological devices. Through this method, chronic diseases or specific conditions, such as heart disease, diabetes mellitus or asthma can be managed. These services are advantageous in terms of comparable health outcomes to traditional in-person patient encounters, greater satisfaction to patients and cost-effectiveness.
- For real-time interactions between patient and provider, Interactive telemedicine services are developed. They include phone conversations, online communication and home visits. Many activities such as history review, physical examination, psychiatric evaluations and ophthalmology assessments are some activities that can be conducted. Additionally, the cost of 'clinician-interactive' telemedicine services is much lesser than in-person clinical visits.

### *Benefits and Uses of Telemedicine*

For populations living in isolated communities and remote regions, telemedicine proves to be a boon of technical advancement. It is currently being applied in virtually all medical domains. Telemedicine serves as an effective tool for communication between a general practitioner and a specialist available at a remote location.

On the other hand, the emerging new way of practicing telemedicine in developing countries is called as Primary Remote Diagnostic Visits, whereby devices

are used to remotely examine and treat a patient. This proves to be promising for countries like India because Primary Remote Diagnostic Consultations monitors an already diagnosed chronic disease with additional promise to diagnose and manage the diseases for which a patient will typically visit a general practitioner.

**IMPORTANCE OF TELEMEDICINE**

- Remote area connectivity for medical facilities.
- Urgency of consultation like eye treatment, etc.
- Treatment and consultation of contagious disease like Ebola, etc.
- In India, Panchayat's Primary Health Centres (PHCs) can be connected through telemedicine facilities.
- Cost benefit for patients.
- Speedy diagnosis and treatment facility.
- Can provide health care to the neglected sections of society like elderly people, children and women.
- Issue with telemedicine.
- There is need for security and privacy. Private information need not to be made public.
- Electronic versions of sensitive documents such as 'X-ray' or 'Doctor's notes' must be as secure as paper ones.

**Telehealth** delivers health-related services and information via telecommunication technologies. In simpler words, it is like two health professionals discussing a case over the telephone, or as sophisticated as using videoconferencing between providers at facilities in two countries, or even as complex as robotic technology.

The expansion of telemedicine is Telehealth. It encompasses preventive, promotive and curative aspects (focus of telemedicine). Today, telehealth stresses a myriad of technology solutions in addition to administrative or educational functions related to telemedicine. For instance, the physicians can communicate with patients, prescribe drugs and provide other health services via email.

**eHealth** eHealth is a relatively recent term that involves healthcare practices done with the help of electronic processes and communication.

**mHealth** mHealth or mobile health defines the practice of medical and public health, with the help of mobile devices, like using mobile phones and PDAs, for health services and information. It works as a sub-segment of eHealth. It is another important application of Information and Communication Technology (ICT), deploying computers, mobile phones, communications satellite, patient monitors, etc., for health services and information.

Stemmed from the rapid rise of mobile phone penetration in low-income nations, eHealth has emerged largely in developing nations.

## 12.28 AMBIENT INTELLIGENCE

- Ambient Intelligence (AmI) is a setup of electronic devices that observes records, analyses and responds to the human environment.
- They have the ability to model user behaviour, activity prediction and recognition, decision-making and controlling.
- AmI primarily aims to broaden the interaction between human beings and digital information technology through the use of ubiquitous computing devices.
- AmI comprises three main components: ubiquitous computing, ubiquitous communication and user-adaptive interfaces.

### *Importance of Ambient Intelligence*

- It has a wide range of applications like Smart homes, which smartly interact with residents; health-related applications, where patients' activity can be monitored, analysed and quick and automatic decisions can be taken; public Transportation System, where traffic can be managed efficiently.
- It poses security issue and privacy challenges.

## 12.29 SPECIFIC ABSORPTION RATE (SAR)

It is a standard for safe exposure to radio frequency. SAR is measured as the amount of radio frequency or electromagnetic frequency absorbed per unit mass of tissue or human body. It is measured in units of watts per kilogram. It has gained importance because of high exposure of human beings to mobile radio frequency. It is assumed that exposure of human tissue to high frequency can cause mutation and gene transformation. Hence, to meet the health standard, FCC (Federal Communication Commission) has come up with a standard that is tolerable by human body. SAR level of 1.6 watts per kilogram (1.6 W/kg) is the FCC limit

for public exposure from cellular telephones. India Department of Telecommunication, has come up with SAR regulation to check electromagnetic radiation to address health concerns and regulate mobile manufacturing industry.

## 12.30 PROJECT LOON

It is a research and development project developed by Google X with a network of balloons travelling on the edge of space. It is designed for connecting people in rural and remote areas, thus enabling to fill coverage gaps, and bring people back online post disasters. The balloons float in the stratosphere, approximately 20 kilometres above the Earth's surface that is twice as high as airplanes and the weather. Stratosphere has many layers of wind, and each layer of wind varies in terms of direction and speed. Loon balloons move rising or descending into a layer of wind blowing in the desired direction of travel, when needed. The balloons can be arranged to form one large communications network with moving wind, then the signal is passed across the balloon network and back down to the global Internet on Earth and ultimately connected to the balloon network directly from the phones and other LTE-enabled devices.

In June 2013, Project Loon began with an experimental pilot basis in New Zealand, where this technology was tested. The stratosphere is situated (between 10 km and 60 km in altitude) with unique engineering challenges like low air pressure of 1 per cent at sea level, being so thin that it offers less protection from UV radiation and dramatic temperature swings, which can reach as low as –80 degrees centigrade. The balloon envelope has been carefully designed to withstand these conditions, and hence, Project Loon is able to take advantage of the stratosphere's steady winds and remain well above weather events, wildlife and airplanes. A balloon envelope is the inflatable part of the balloon made from sheets of polyethylene plastic. To allow a balloon to last around 100 days in the stratosphere, it needs to be carefully designed.

### *The Benefits on Google Loon*

It would be easy to use; no need to setup wired network and other complexities would be eliminated.

- High-speed Internet all over globe without glitches.
- It will increase Internet penetration and subscriber base.
- The biggest advantage would be its extension to those areas where Internet expansion is either complex or not possible; like forests, deserts, mountains, hilly areas, etc.
- Also the remote areas will get affordable Internet communication, which they have been deprived of till now.
- Hence, it will bridge the gap of Internet distribution and provide equal accessibility to all.

## 12.31 TRP RATING CONTROVERSY

Television Rating Point system is an indicator of the popularity of a channel. It rates channels on the basis of viewership. TRP rating is calculated on the basis of duration of time and the channel viewed by the viewer on a daily basis and finally, at the end of the month, it is averaged. This data is important for advertisers, as they have to pay on this basis. The sole agency which measures viewership and TRP ratings is known as Television Audience Measurement (TAM) Media Research.

### *What is Controversy?*

- Based on the TRP, advertising rates are determined.
- Major broadcasting firms like NDTV, MSM, etc., have blamed TAM for manipulating the TRP and called it as flawed data that pays them nothing.
- With the increase in household televisions, TRP should go up but it has decreased, indicating that the viewership has decreased.
- This decreasing viewership data is a major concern, which fetches less advertisement fees from advertising companies, thus reducing their revenue collection.

### *Solution*

- TAM has decided to shift rating system to a new system based on absolute number of viewers.
- Television viewership will now be measured on the basis of Television Viewership in Thousands (TVTs), which is based on absolute numbers of viewers rather than TRP, which was based on averaged points.
- All stakeholders' broadcasters, advertisers, ad-agencies and TAM, later agreed to it.

## 12.32 QR CODES AND ITS APPLICATIONS

Codes are shortcuts to identify something. Bar codes are very often used to identify an article's properties. These bar codes can store information into them but they have some limitations. A dedicated device like infrared reader is used to decode the bar codes. There is need to next-generation code that can meet the demand of time. QR code means Quick Response code. It can be said to be the next-level bar code with enhanced features. QR code is a two-dimensional code unlike bar code, which is one-dimensional. It can store more information than bar codes. A 30 per cent error can be tolerated by QR code. Tampered QR codes can be easily read. It provides a robust coding technology. QR codes can store diverse information like Web URLs, Pictures, Text Information and Numbers, etc. There is no need of dedicated devices. Smartphone cameras and other digital cameras are enough to scan these codes. Simple and easily installable software is needed that translates the bar code into information coded into it. It has wide applications from town planning to enterprise. It is being used in business marketing. Monmouth in South Wales was converted into 'Wikipedia Town' by putting QR Code Markers at every point. A tourist just needs to scan the code to get the information about the place.